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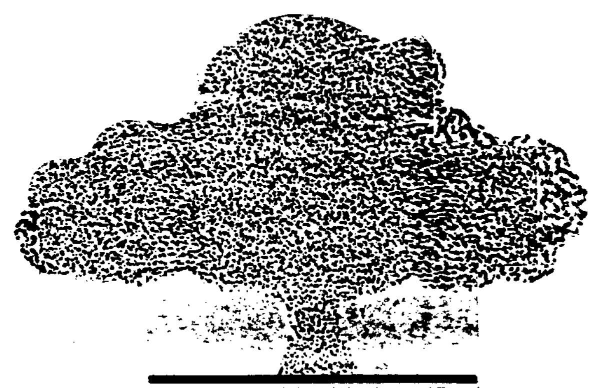
Operation BUSTER - JANGLE

NEVADA PROVING GROUNDS
OCTOBER - NOVEMBER 1951

INSTRUMENTATION OF B-50, Sanitized Version



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INSTRUMENTATION OF B-50

Operation Buster

Prepared by

4925th TEST GROUP (ATOMIC)

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Special Weapons Center
Kirtland Air Force Base
Albuquerque, New Mexico

April 1952

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PREFACE

This report describes the special air instrumentation carried by delivery aircraft of the 4925th Test Group (Atomic) during Operation Buster. The instrumentation was intended to cover three main fields, two of them experimental and the other operational. The release-tone equipment described in the report was essentially a part of the timing system for all instrumentation on the ground and was the operational phase. This equipment was designed and installed by the Sandia Corporation for use in ballistic work at Salton Sea. Appropriate receiving equipment was built by Sandia and was adapted for use with the Edgerton, Germeshausen & Grier timing equipment at the Nevada Proving Grounds.

The experimental instrumentation resulted from requests by two agencies, the United States Air Force, through the Wright Air Development Center (WADC) and the Strategic Air Command (SAC), and the Atomic Energy Commission, through the Los Alamos Scientific Laboratory. The disk camera, Bhangmeter, and transit-time equipment were installed as parts of the formal Projects 10.3 and 10.2. The instrument panel containing indicators of altitude, airspeed, etc., and the recorder for measuring shock-arrival times were installed at the informal request of LASL. The purpose of this latter installation was primarily to obtain range information for use with the disk camera. Generally speaking, the installation requested by LASL was an extension of a program that had been originally drawn up for Operation Greenhouse and had been later abandoned because of changes in the Greenhouse schedule.

The Indirect Bomb Damage Assessment (IBDA) program sponsored by WADC was included at the request of AFSWP at a very late date. A more elaborate program had been planned for Operation Jangle, and considerable work had already been done at Operation Greenhouse. The installation for Operation Buster was very little different from that originally attempted by SAC during Operation Ranger. SAC, through strictly Air Force channels, also expressed a very strong interest that IBDA work be included on Operation Buster.

GAELEN L. FELT
Los Alamos Scientific Laboratory

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CHAPTER 1

INTRODUCTION

By Otis R. Hill

1.1 PURPOSE OF REPORT

The purpose of this report is twofold: First is the consolidation of all information gathered by instruments aboard B-50 No. 7169 during the Buster phase of the nuclear tests conducted at the Atomic Energy Commission (AEC) Nevada Proving Grounds (NPG) in October and November 1951. No attempt is made to interpret any of the results. They are presented in this report for the various agencies who requested the information. Second is an evaluation of the Edgerton, Germeshausen & Grier (EG&G) measuring instrument, the Bhangmeter. The adaptability of the Bhangmeter for Air Force use is also discussed.

1.2 BACKGROUND

Two letters delegating authority for the project were issued in September and November 1951. The first directive was the result of conferences held by Los Alamos Scientific Laboratory (LASL), EG&G, and 4925th Test Group (Atomic) personnel and was the initial directive to install instruments in B-50 No. 7169 for Operation Buster. The second letter directed that a report include data relative to the Indirect Bomb Damage Assessment (IBDA) program. The requests contained in these letters are given in Appendix A.

The AEC nuclear tests of January and February 1951 (Operation Ranger) at Frenchman Flat, Nev., were conducted to gather preliminary data for the Eniwetok Greenhouse tests. Because of results determined from the Nevada tests, the airdrop previously scheduled for Greenhouse was canceled. EG&G had developed airborne instrumentation for Greenhouse, but with the cancellation of the airdrop this equipment was not used during flight. Operation Buster was the first airborne test of the EG&G disk camera and the first test of any kind for this model of the EG&G airborne Bhangmeter. Ground tests were made on an earlier model of the airborne Bhangmeter at the Nevada tests in January and February 1951 and at Eniwetok in the summer of 1951.

LASL stated that accurate times from release to detonation to shock-wave arrivals would be useful in their analysis and requested that this information be obtained. Massachusetts Institute of Technology Project Locus stated an interest in the same information. Gathered in conjunction with the above information were drop-aircraft course, altitude, and airspeed.

Wright Air Development Center (WADC), Dayton, Ohio, requested that several cameras be carried as part of their IBDA program. These cameras were used in an attempt to determine the point of detonation and the yield.

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Experience gained in instrumentation during Operation Buster has further increased the capability of the 4925th Test Group (Atomic) to gather important data during nuclear tests.

1.3 DISCUSSION OF INSTRUMENTATION

A brief description of the instrumentation of B-50 No. 7169 follows; in Chap. 2 the instrumentation is described in detail, and a list of the equipment used is given in Appendix B.

1.3.1 Equipment Installed for EG&G Program 10.3

(a) Disk Camera. Figures 1.1 to 1.3 show the disk camera. This camera records fireball growth in the form of streaks on a rotating light-sensitive plate. Necessary associated equipment includes an intervalometer to start the camera after a designated time from release, a photoelectric-cell pickup (Figs. 1.4 and 1.5) that receives initial bomb light, a frequency standard and marker (Fig. 1.6) that place detonation and timing marks on the disk, and a trigger box (Fig. 1.6) that caps the shutters at the appropriate time.

The disk camera presented no particular problem in either installation or operation. Additional capacity was added to the circuit of the trigger box to ensure shutter closure. This was done to correct a failure which occurred on a check-out.

(b) Bhangmeter. This instrument records the bomb-light curve in such a manner that the time to minimum can easily be ascertained. Since this time is a function of the yield, the yield of the bomb can be readily determined. The Bhangmeter is a self-contained unit weighing approximately 25 lb. Figure 1.7 shows the Bhangmeter and photoelectric-cell pickup head. The Land Polaroid camera is in place. Figure 1.8 shows the Bhangmeter with camera and covers removed. The approximate dimensions are 6 by 12 by 16 in. The photohead is in the foreground, and the camera is on the left. Figure 1.9 shows the Bhangmeter in various stages: The assembly on the left is complete except for camera, cover, and pickup head; the assembly in the center is the battery pack; and the assembly on the right is the electronic section of the Bhangmeter. Figure 1.10 shows the Bhangmeter installed at the left-scanner's position, and Figs. 1.11 and 1.12 show the two photoelectric pickup heads in position in the left blister.

The Bhangmeter was very easy to install, operate, and maintain. Since all drops were made in optimum weather, the fireball was viewed directly by the photoelectric-cell pickup. Light intensity was reduced in one pickup head by the insertion of a neutral-density 0.3 filter, and the resultant curve was easier to interpret. Since all the Buster drops were made in clear weather, the question of the ability of the Bhangmeters to register the light curve accurately through extreme weather conditions naturally arises. EG&G obtained results on the underground Jangle detonation with Bhangmeters, identical to those carried in B-50 No. 7169, which were located at the Command Post 11 miles distant. This was not a direct observation of the fireball and hence could be compared to the observation of a detonation through heavy cloud cover. The sensitivity of the pickup head can be increased, and the possibility exists of having two pickup heads of different sensitivity for observations under varied weather conditions.

The first Bhangmeter reading (Buster [redacted] was given as "no result" because of an unanticipated characteristic of the instrument. When the trace is triggered with the photoelectric-cell input at zero signal level, a horizontal trace is momentarily shown on the tube face. When bomb light triggers the circuit and the light curve is traced, the curve minimum can trail off to a horizontal line (see Fig. 1.13c). This makes a minimum nonexistent when a horizontal-line grid system is used to determine the minimum point. When different steady input voltages are impressed on the photoelectric-cell input and the sweep circuit is triggered, a discharge trace appears on the scope. This trace is formed by a discharge through an RC circuit, and hence the trace departs more and more from the horizontal (see Fig. 1.14a). Once this grid has been determined, it is simple to read the light-curve minimum. The seemingly horizontal tail on the first-detonation light curve actually indicates an increase in light intensity, and

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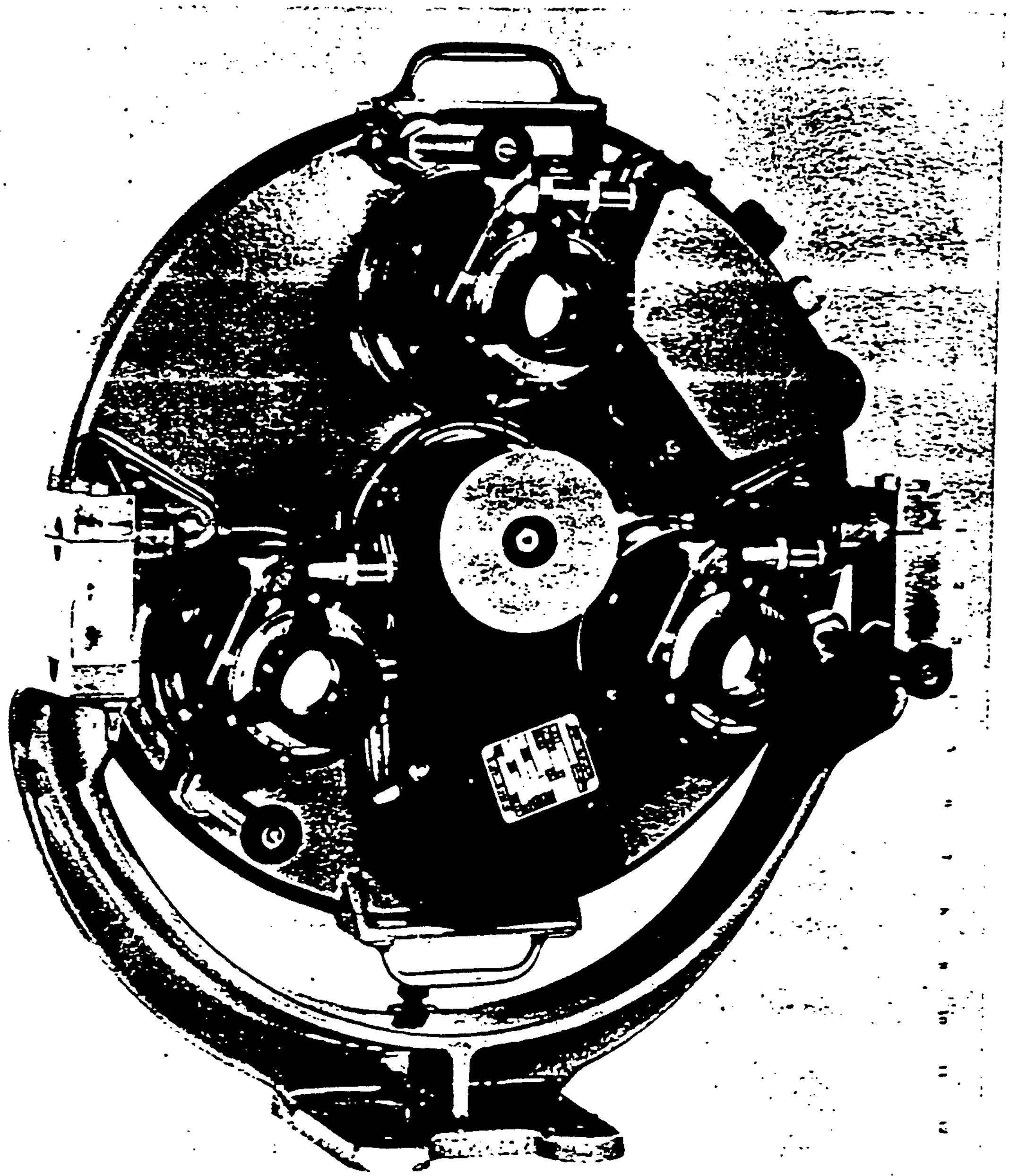

Fig. 1.1—EG&G disk camera, front view.

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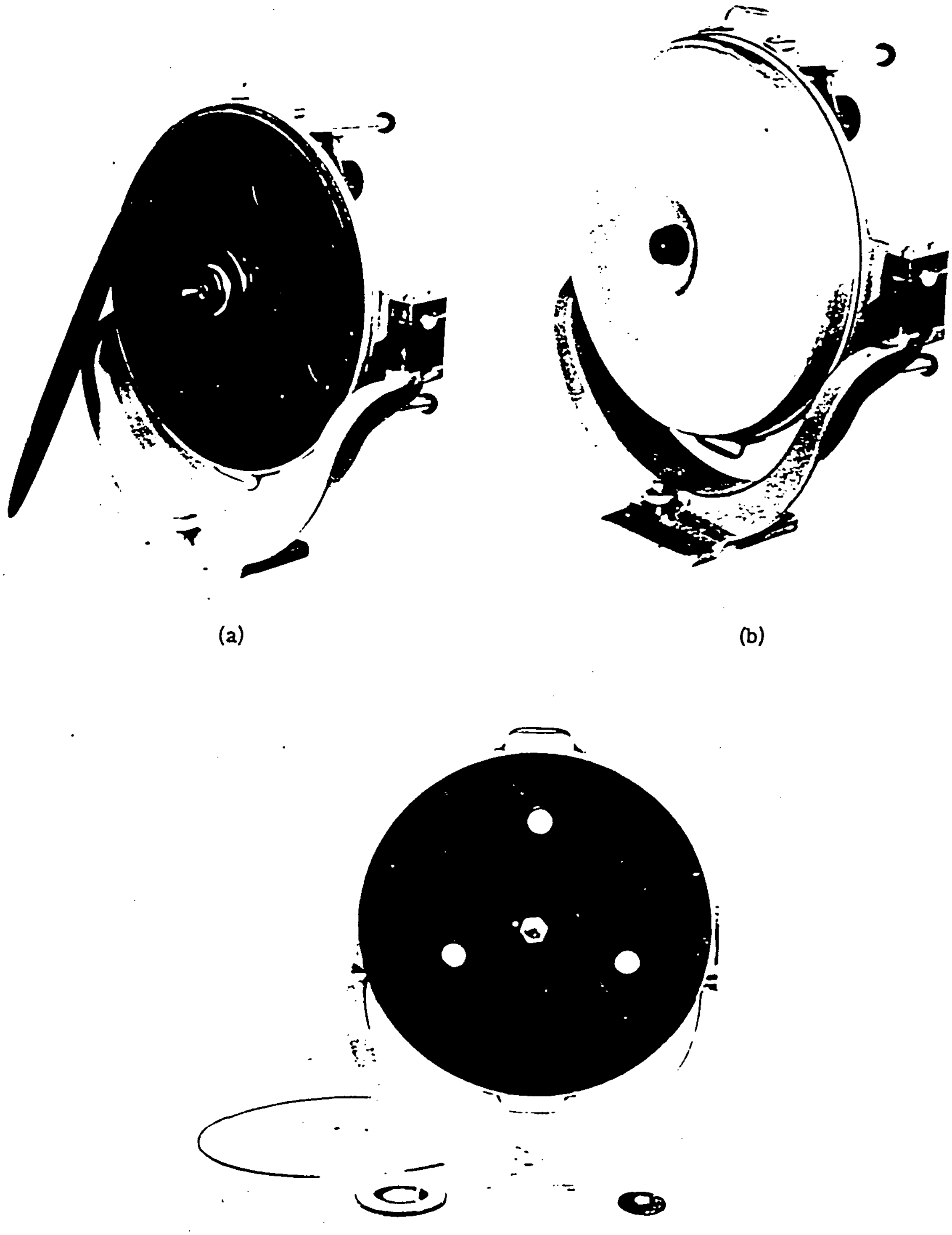

(a) (b) (c)

Fig. 1.2—EG&G disk camera. (a) Rear view, cover removed. (b) Rear view, cover in place. (c) Rear view, cover removed, glass plate in background.

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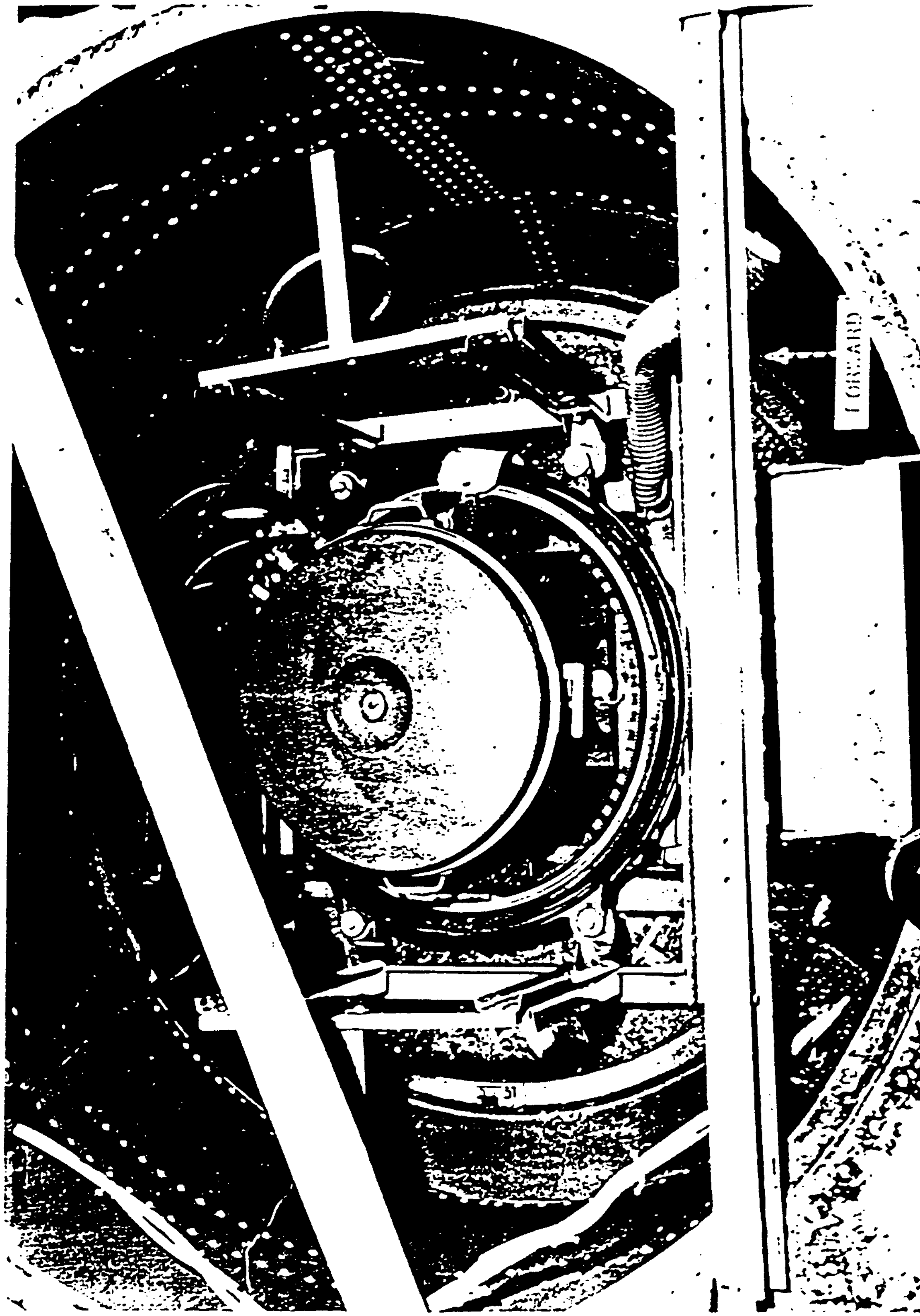

Fig. 1.3—Buster-Jangle B-50 No. 7169, disk camera in lower forward-turret well.

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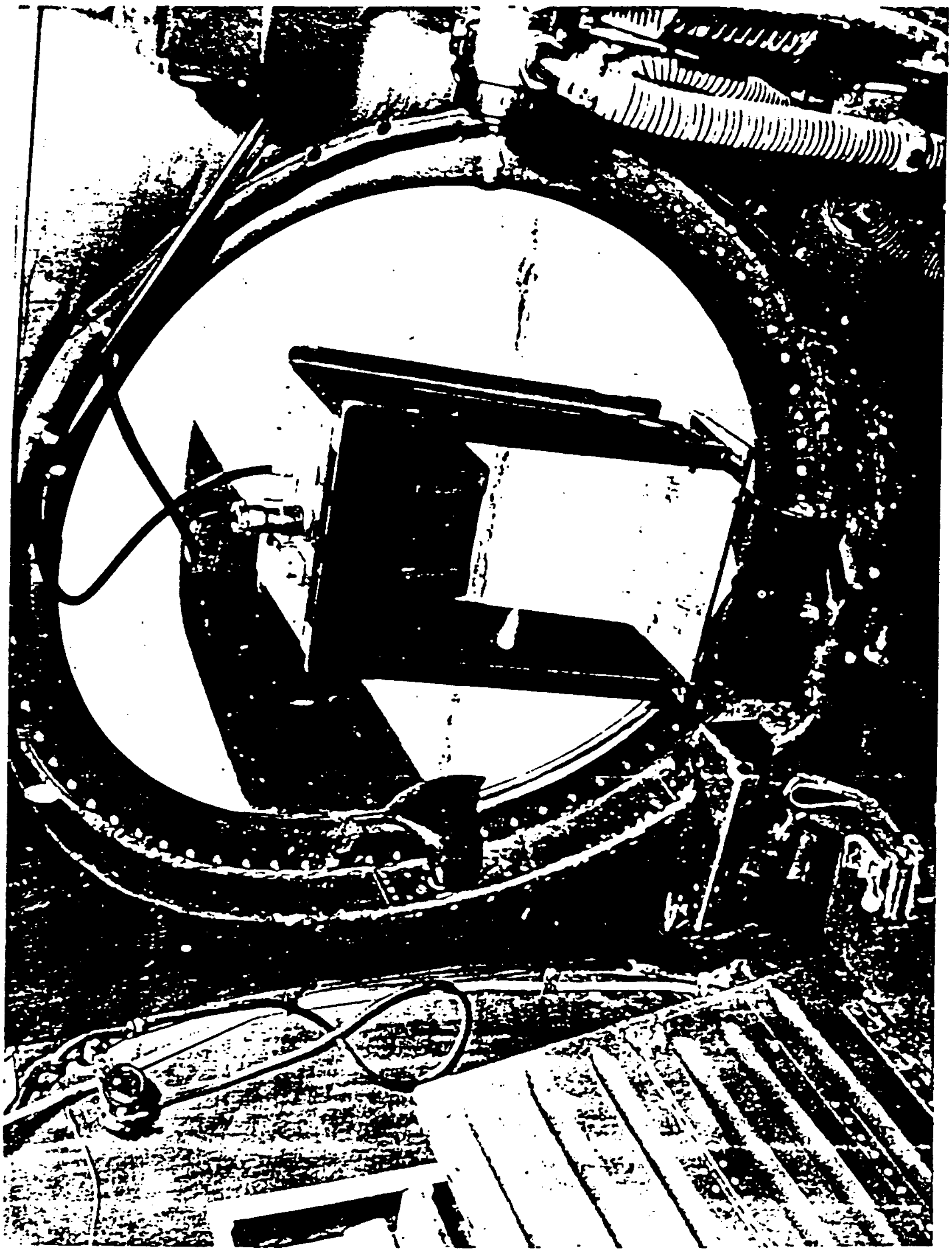

Fig. 1.4—Buster-Jangle B-50 No. 7169, right-scanner's-position disk camera, photoelectric cell; interior view.

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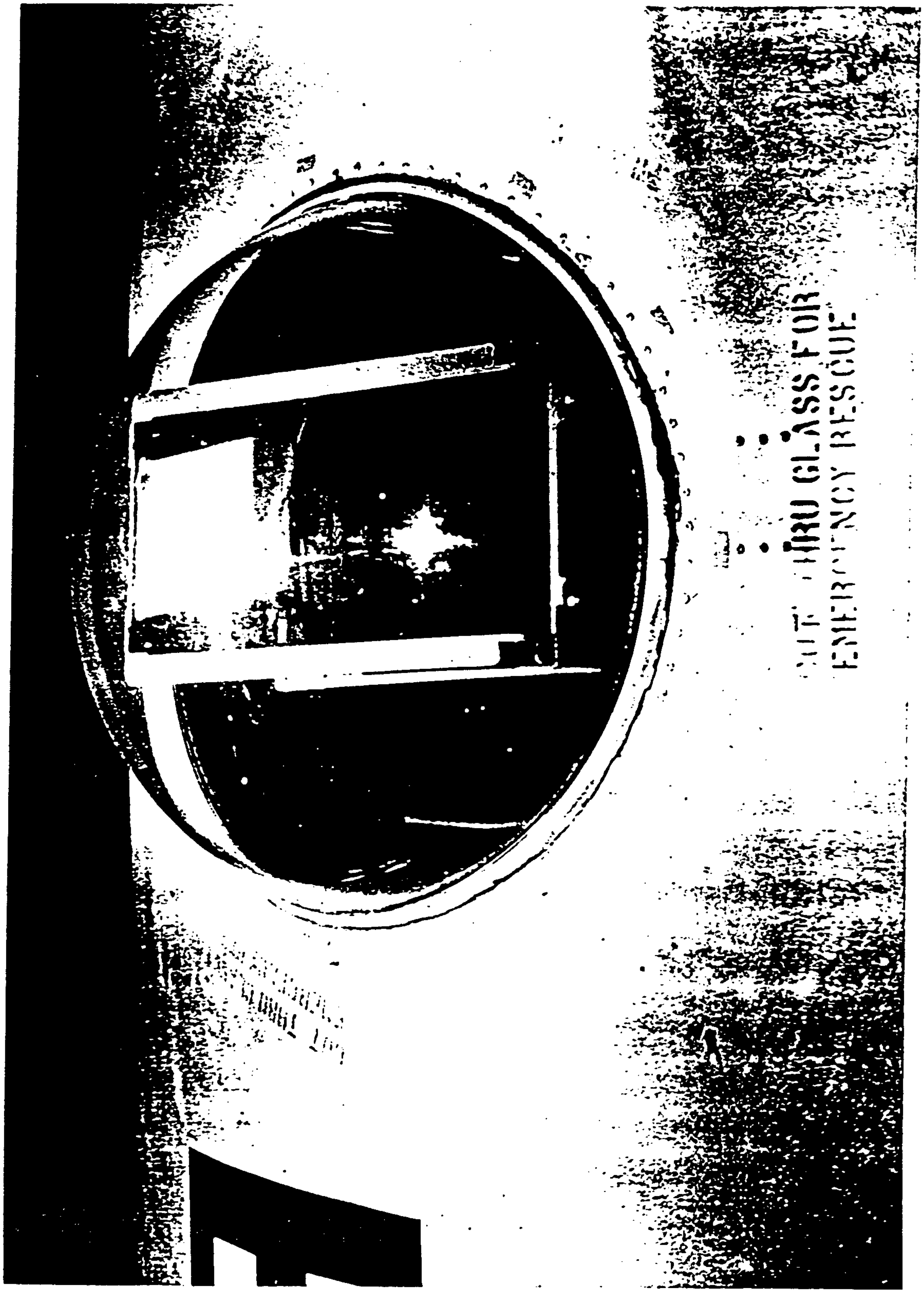

Fig. 1.5—Buster-Jangle B-50 No. 7169, right-scanner's-position disk camera, photoelectric cell; exterior view.

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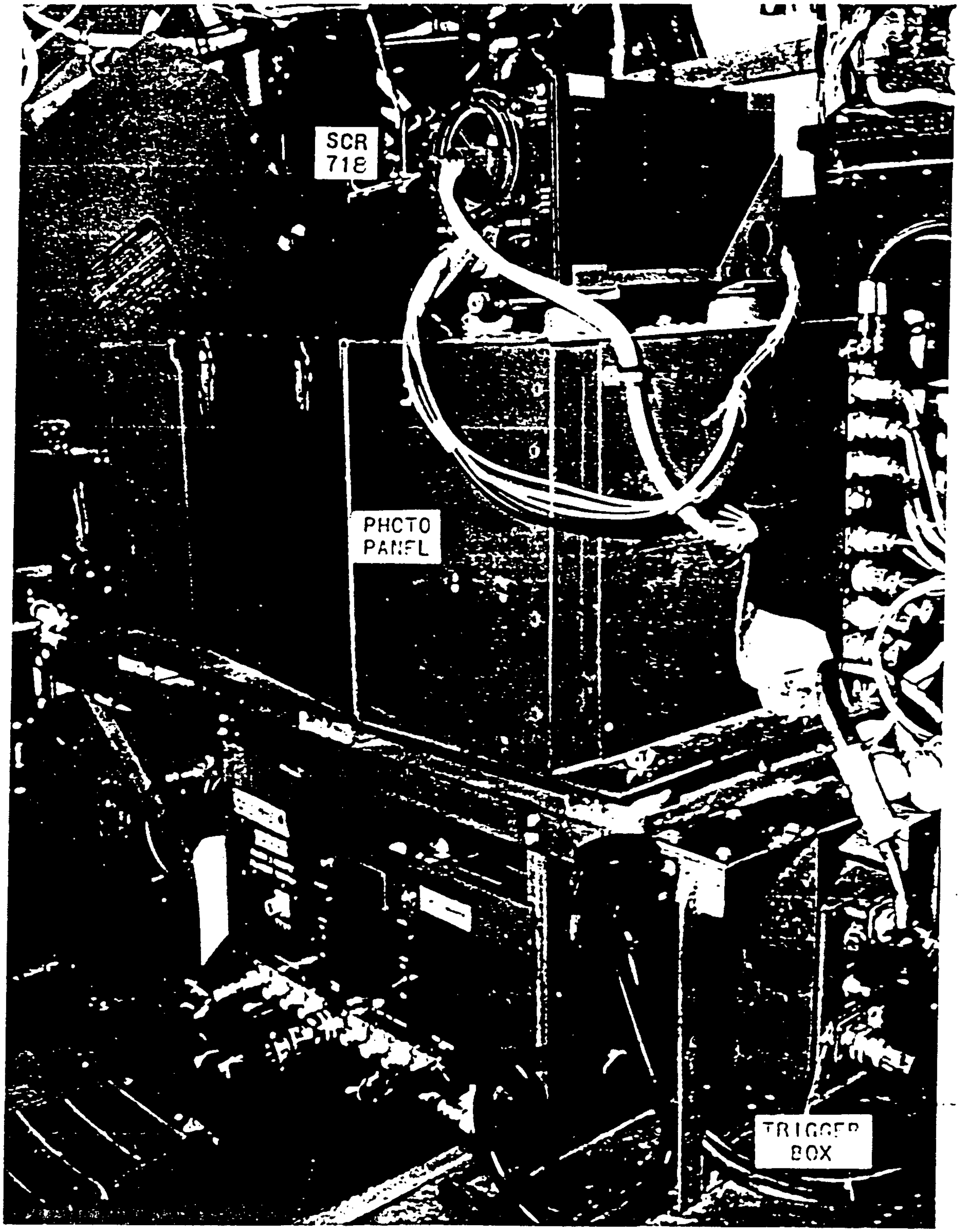

Fig. 1.6—Buster-Jangle B-50 No. 7169, photopanel installation with gated marker and trigger box for disk camera.

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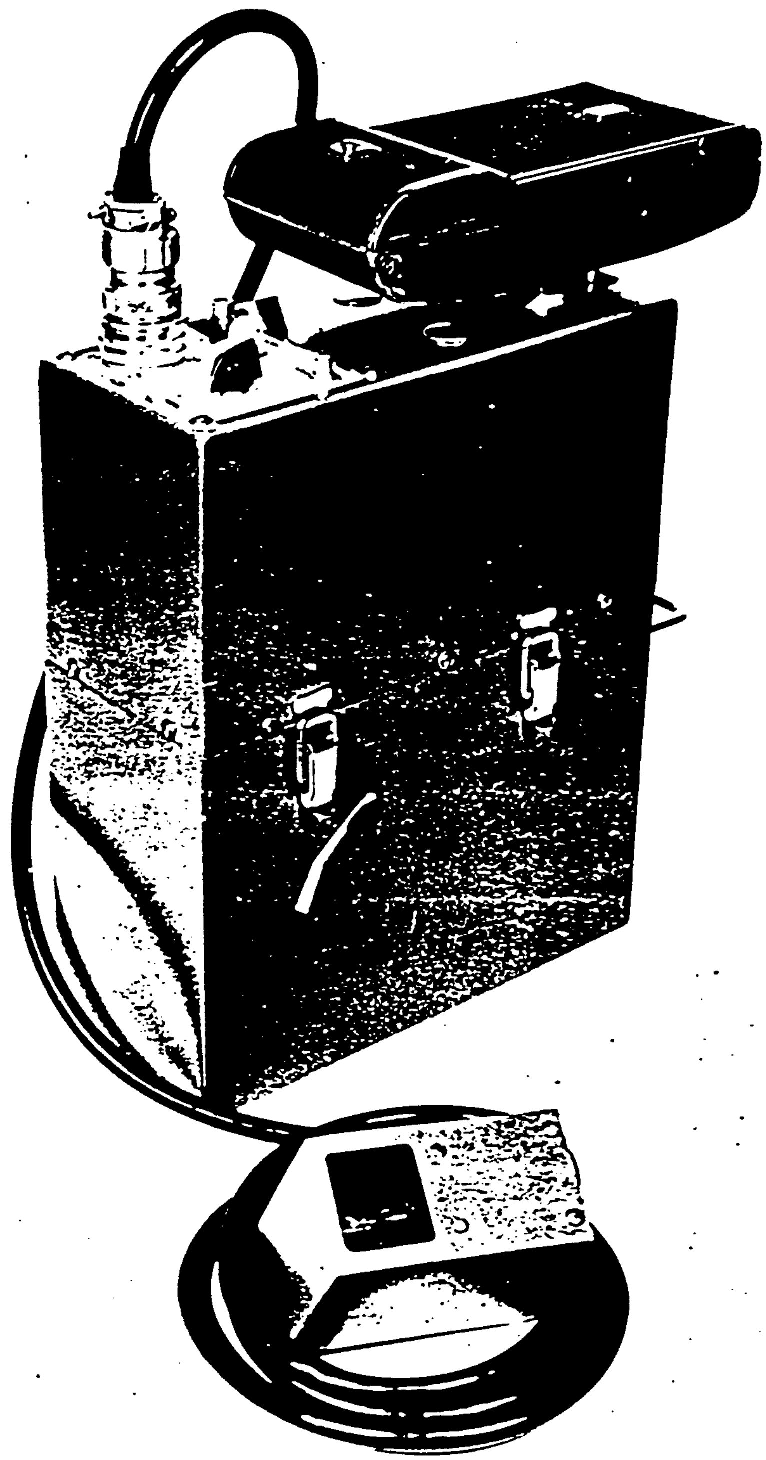

~~Fig. 1.7~~—Airborne Bhangmeter with camera and pickup head.

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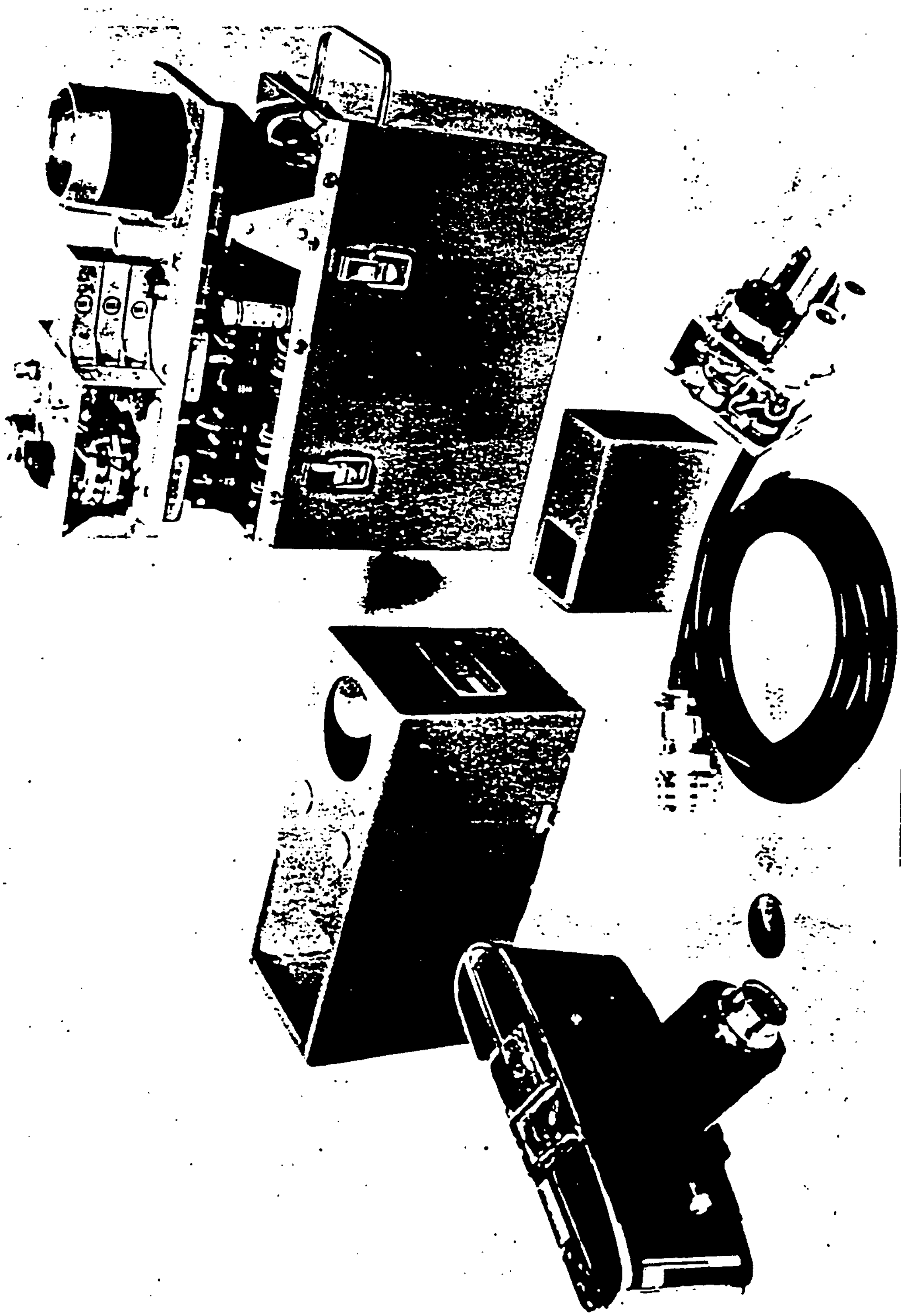

Fig. 1.8 — Airborne Bhangmeter, disassembled.

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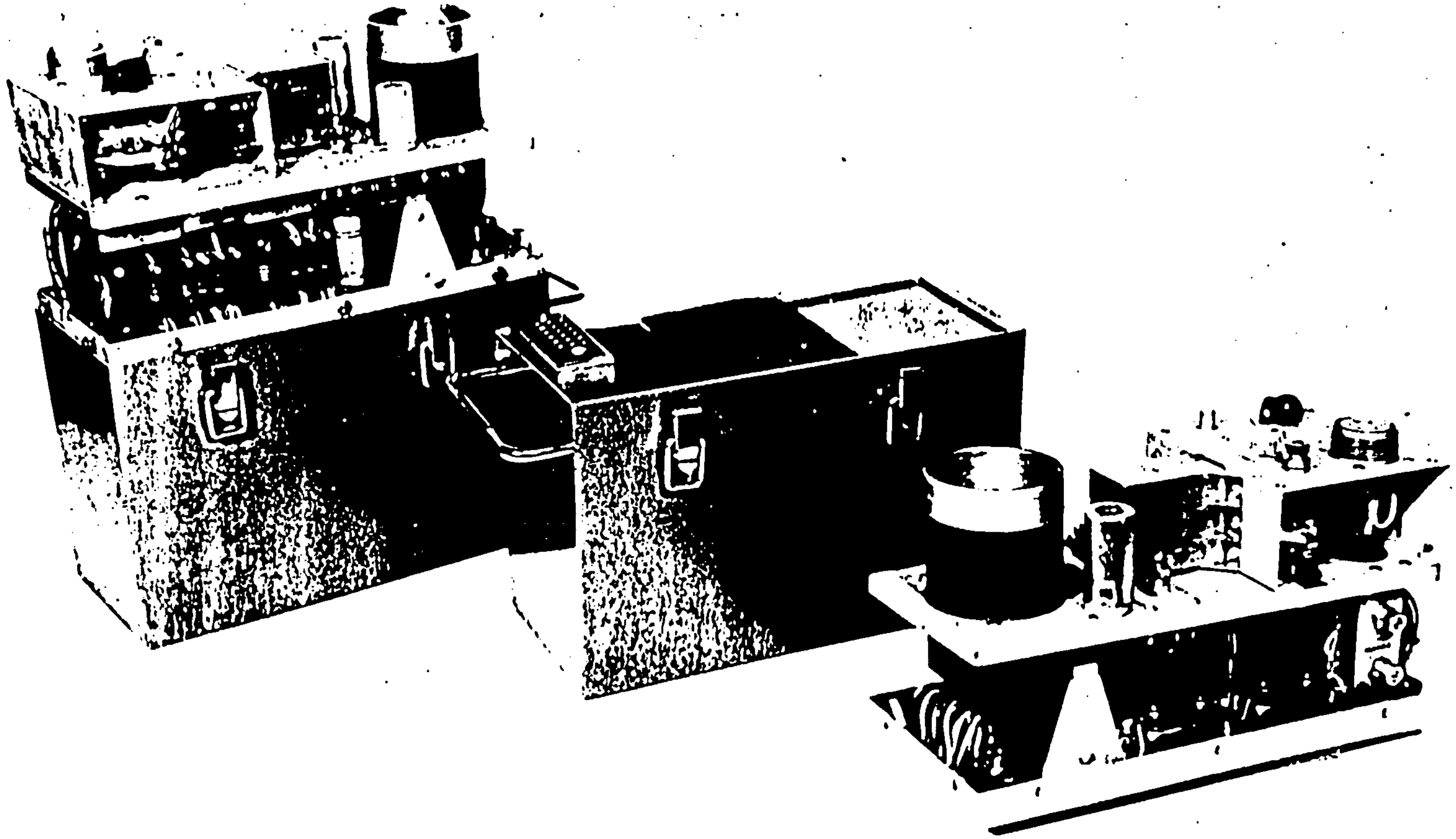

Fig. 1.9—Airborne Bhangmeters, disassembled.

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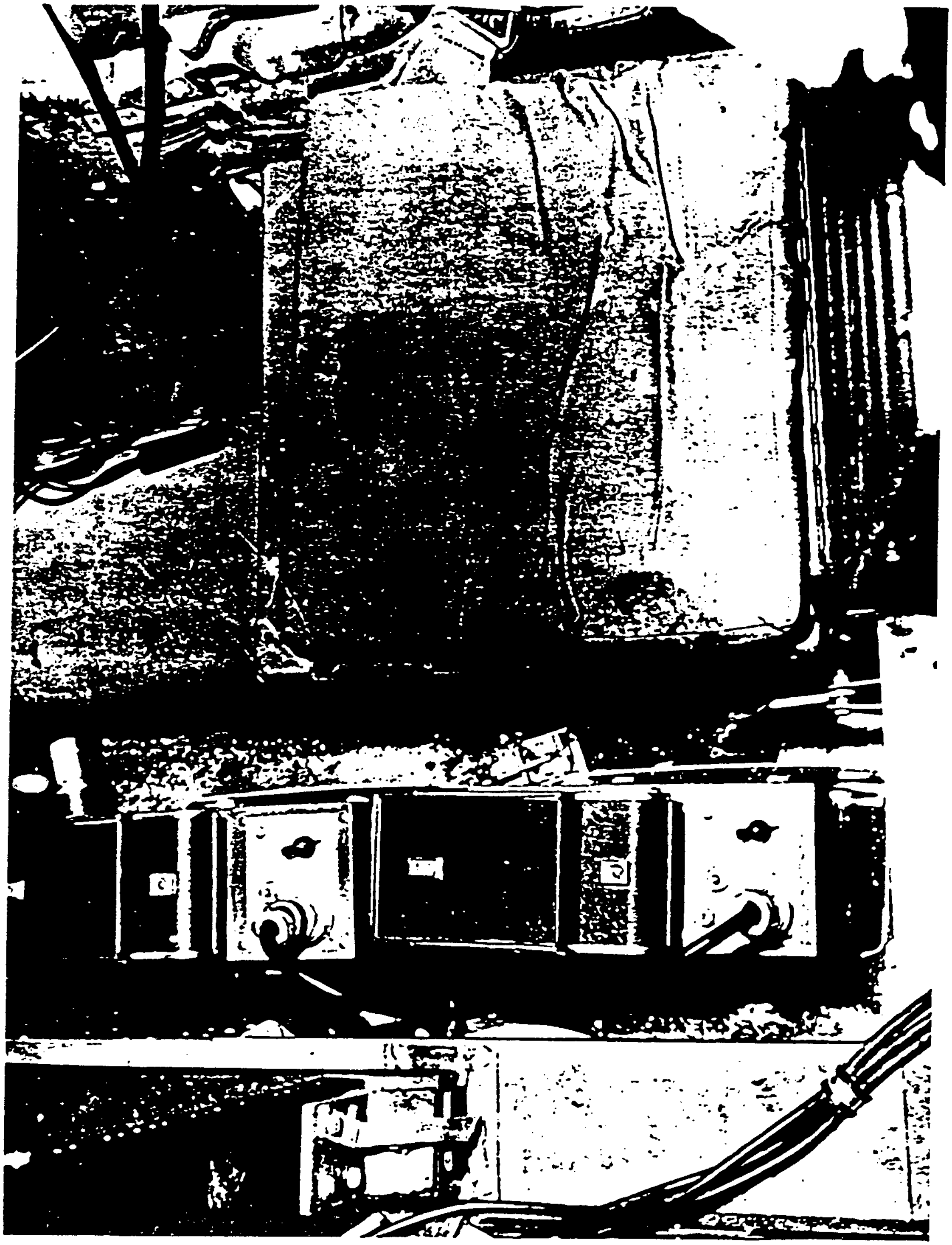

Fig. 1.10—Buster-Jangle B-50 No. 7100, airborne Bhangmeter installation in left-scanner's position.

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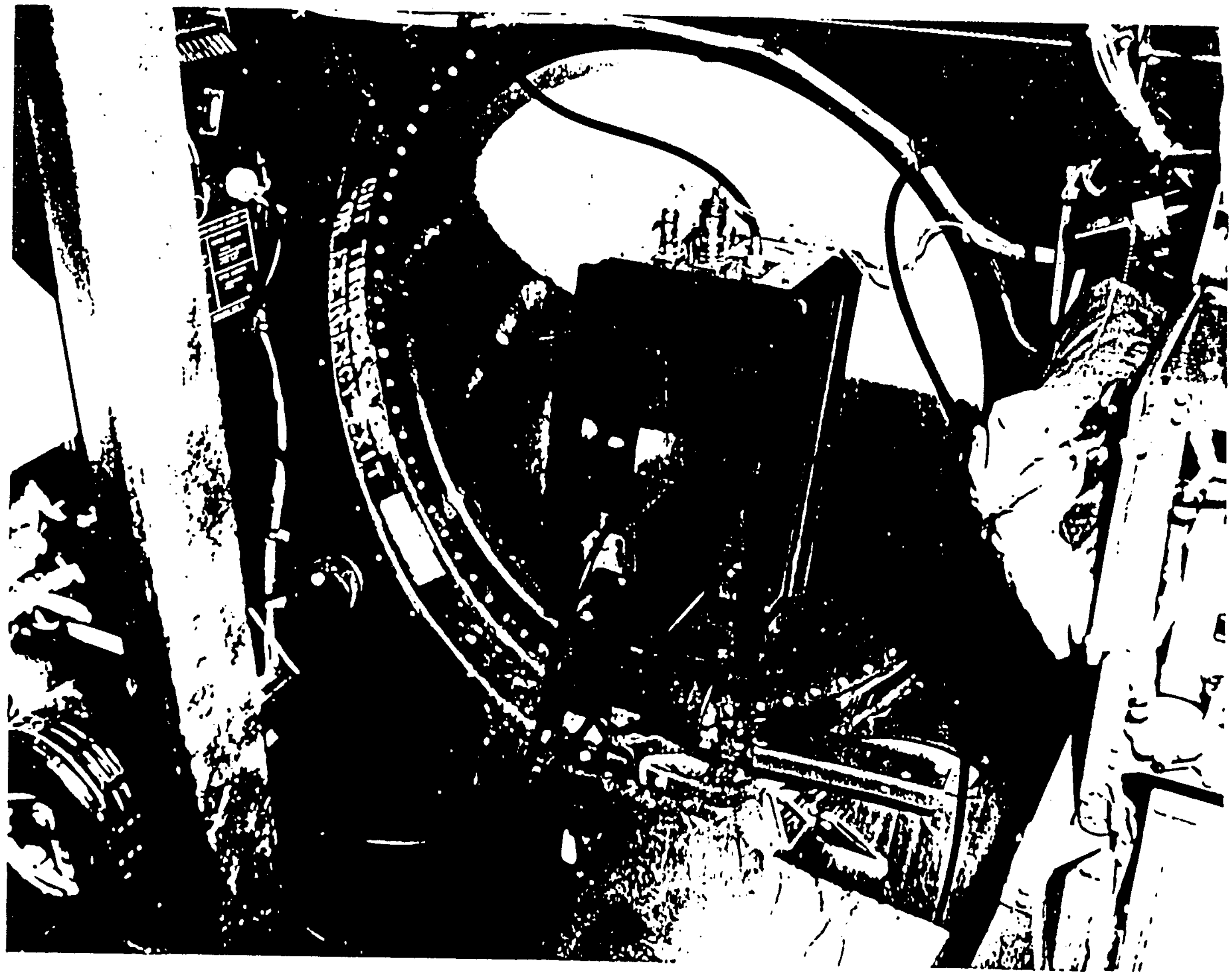

Fig. 1.11—Buster-Jangle B-50 No. 7160, left-scanner's-position time-of-fall photocell pickup and Bhangmeter heads; interior view.

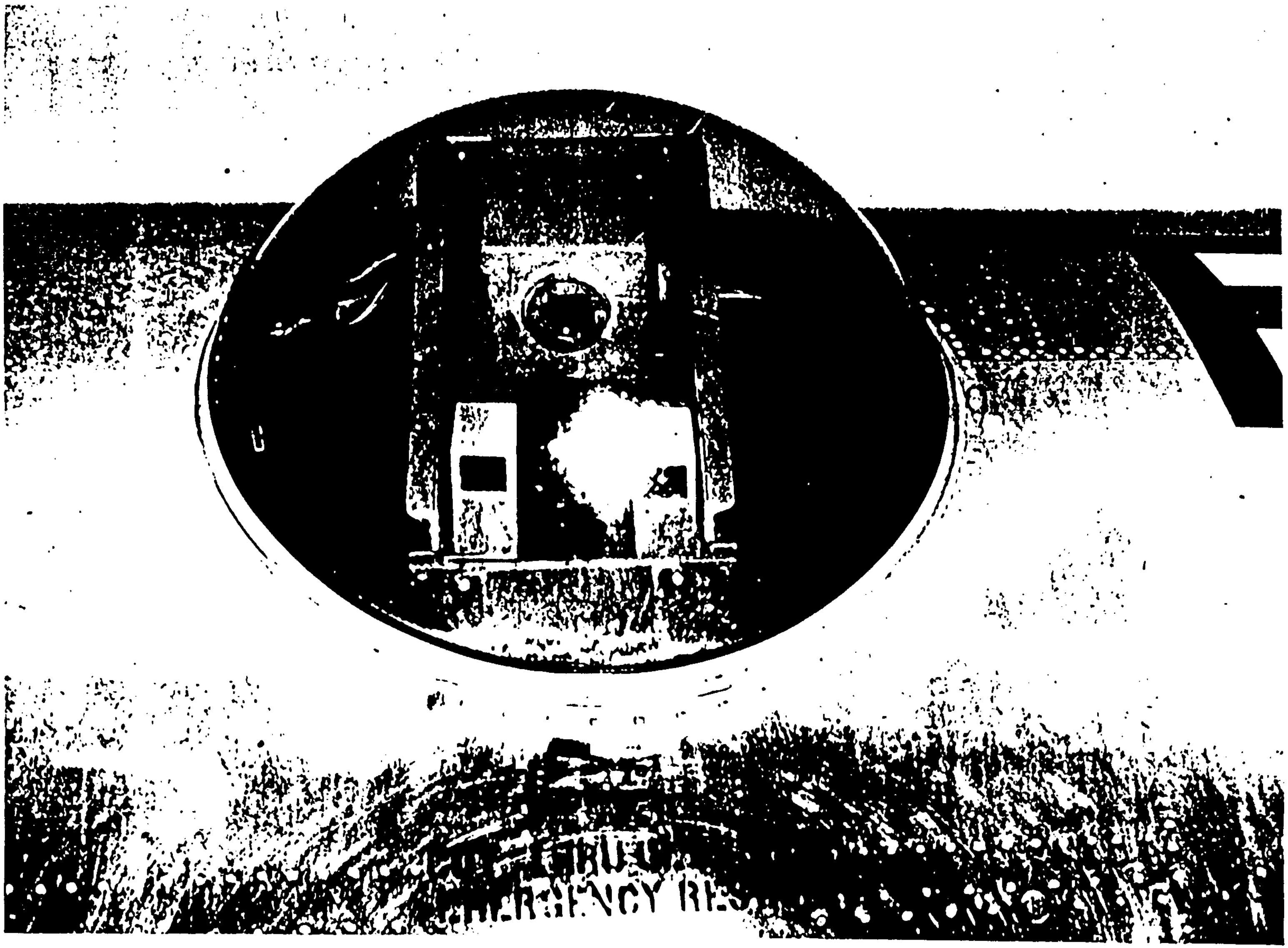

Fig. 1.12—Buster-Jangle B-50 No. 7169, left-scanner's-position time-of-fall photocell pickup and Bhangmeter heads; exterior view.

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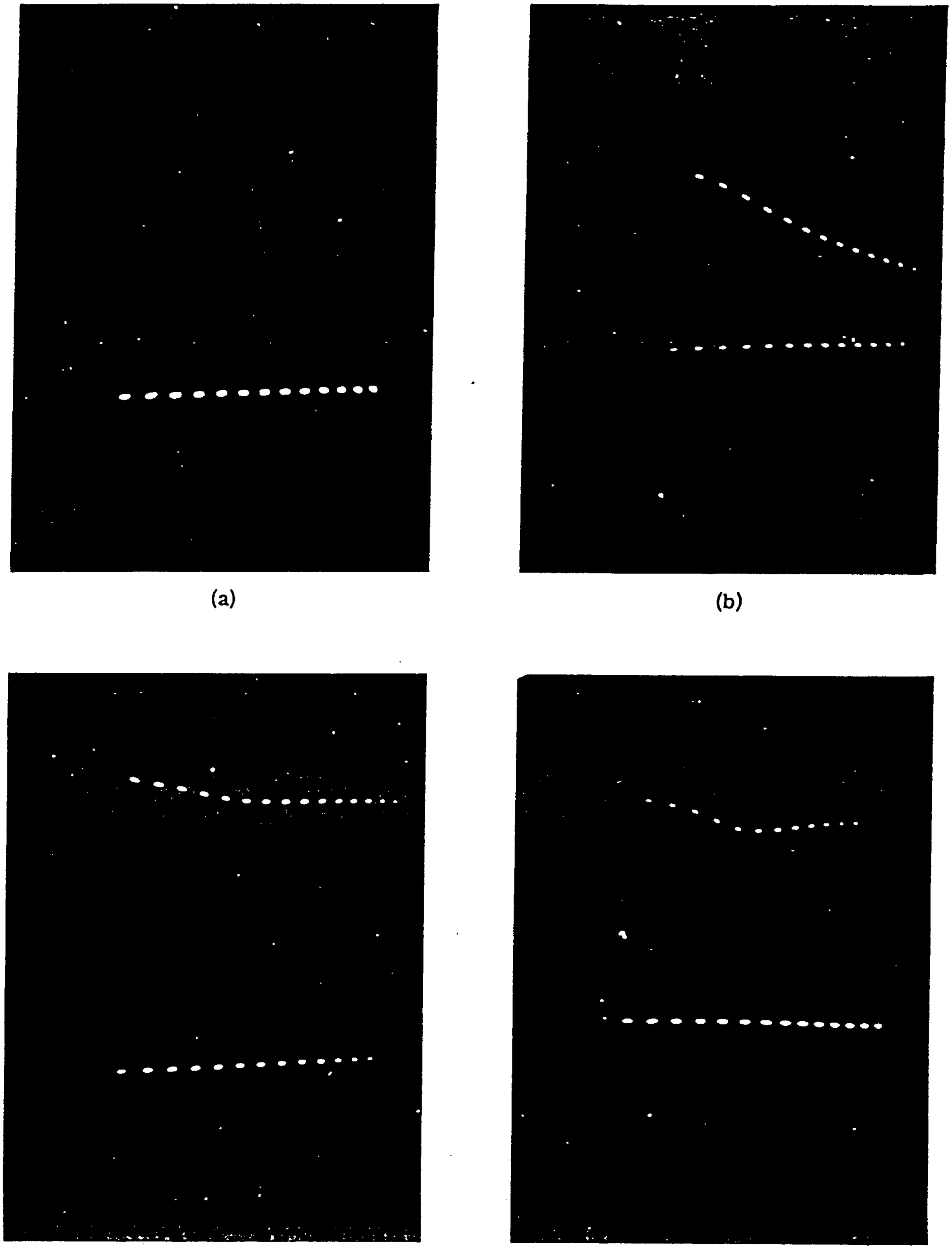

(a) (b)

(c) (d)

Fig. 1.13—Buster Bhangmeter results. (a) No-signal input trace. (b) No-signal input trace and SM type flash-bulb curve. (c) Buster [redacted] Bhangmeter 1 curve. (d) Buster [redacted] Bhangmeter 2 curve.

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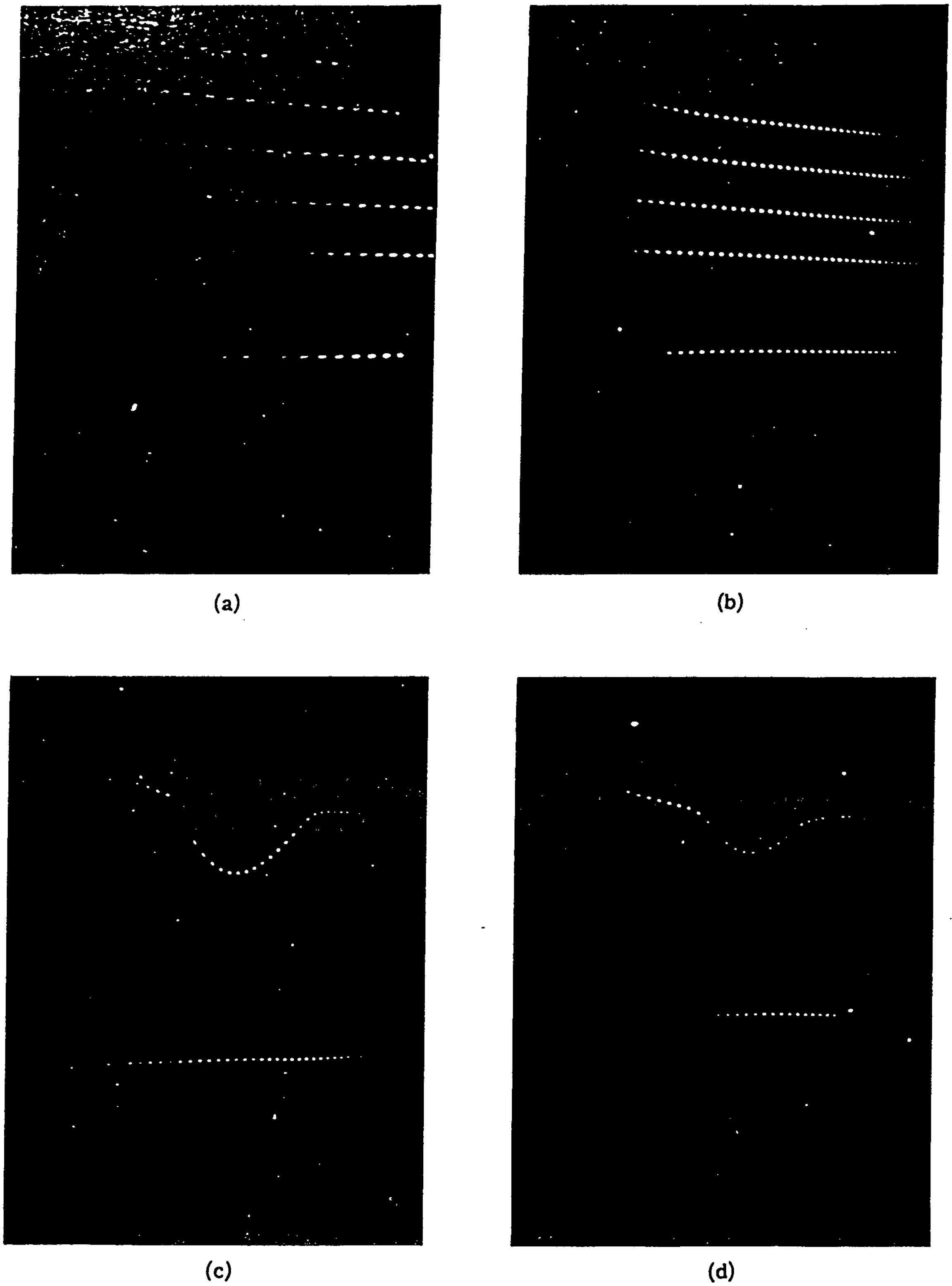

Fig. 1.14—Buster-Bhangmeter results. (a) Preliminary grid prior to sweep-duration increase. (b) Preliminary grid after sweep-duration increase. (c) Buste[redacted] Bhangmeter 1 curve. (d) Buster[redacted] Bhangmeter 2 curve.

[redacted]

therefore the curve minimum can be readily located. No further difficulty was encountered once the grid of static characteristics was recorded for each Bhangmeter.

1.3.2 Equipment Carried for WADC IBDA Program 6.5

(a) K-24 Camera. This camera (Fig. 1.15) was activated by an intervalometer 10 sec prior to burst. Pictures were taken of the detonation, fireball, and cloud every 2 sec.

(b) T-11 Camera. This camera (Fig. 1.16) was activated by a photoelectric-cell pickup of initial bomb light and recorded the fireball and cloud at the rate of three pictures per second.

(c) O-15 Camera. This camera recorded a radar picture of the APQ-24 radar return.

The K-24, T-11, and O-15 camera negatives were released to WADC IBDA program personnel. A preliminary circular error was plotted on a positive print of the detonation. This circular error proved to be very close to the official plotted error. On a day or night combat drop involving no weather interference, it is possible that ground zero could be plotted by using a reliable camera to observe the burst. A set breakaway procedure would establish the proper angle at which to set the camera for viewing the detonation.

1.3.3 LASL Equipment

LASL requested that a record be made of the flight-instrument readings in order that the position of the aircraft at shock-arrival times might be determined. Accurate times from release to detonation to shock-wave arrivals were also requested. The following equipment was used to gather this information:

(a) Instrument Panel. Figure 1.6 shows the photographic panel installed in the forward pressurized section. This panel was installed to record the information concerning radar altitude, pressure altitude, course, indicated airspeed, temperature, release indication, and time.

The photopanel was designed to give optimum readability of the flight instruments. A new type of instrument illumination was successfully tried, and, owing to the improved results with this panel, it will be the standard for all bomber aircraft in the 4925th Test Group (Atomic).

(b) Recorder. A Consolidated Type 5-14 multichannel recorder received indications for release, detonation, and shock arrivals. A frequency standard placed 10- and 100-cps marks on two recorder channels for accurate timing. Accuracy of the recorded data is within ±0.003 sec for the first three drops and ±0.008 sec for the fourth drop. Figure 1.17 shows the recorder, integrating amplifier, and bridge amplifier in position in the rear pressurized compartment.

The means of gathering times from release to detonation to shock-wave arrivals proved highly successful. The original request for information involved only times; therefore no detailed regard was given to waveform. The blast gauges were calibrated prior to each mission, and therefore the recorded peak of the shock waves could be approximately plotted. A timing accuracy of ±0.003 sec was obtained by the system. A detailed description of the equipment and an explanation of the test procedure are given in Chap. 2. In future tests, if similar information is desired, more channels will be used for shock waveform since many agencies have expressed interest in the shock waveform. By making use of the experience gained from this test, much more detailed information can be gathered during future tests.

1.3.4 Telemeter Control

Sandia Corporation Program 1 required the necessary equipment to monitor and control the transit-time telemeter transmitter located within the bomb. The telemeter control is shown in Fig. 1.17.

The transit-time telemeter installation consisted of a monitor and control panel for the transmitter located in the bomb. In order that an accurate account of the condition of the

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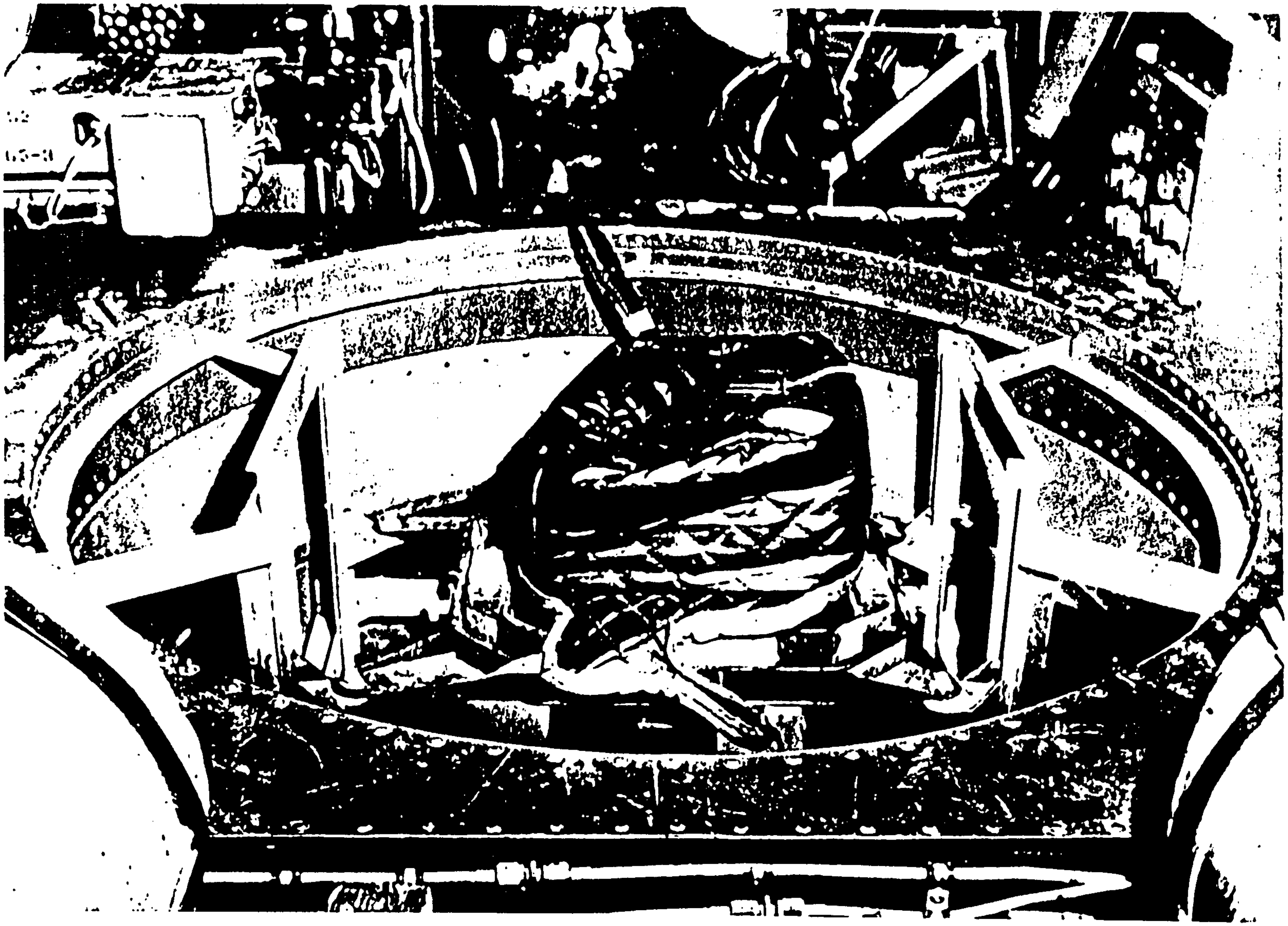

Fig. 1.15—Buster-Jangle B-50 No. 7169, IBDA K-24 camera with cover installation in lower rear-turret well.

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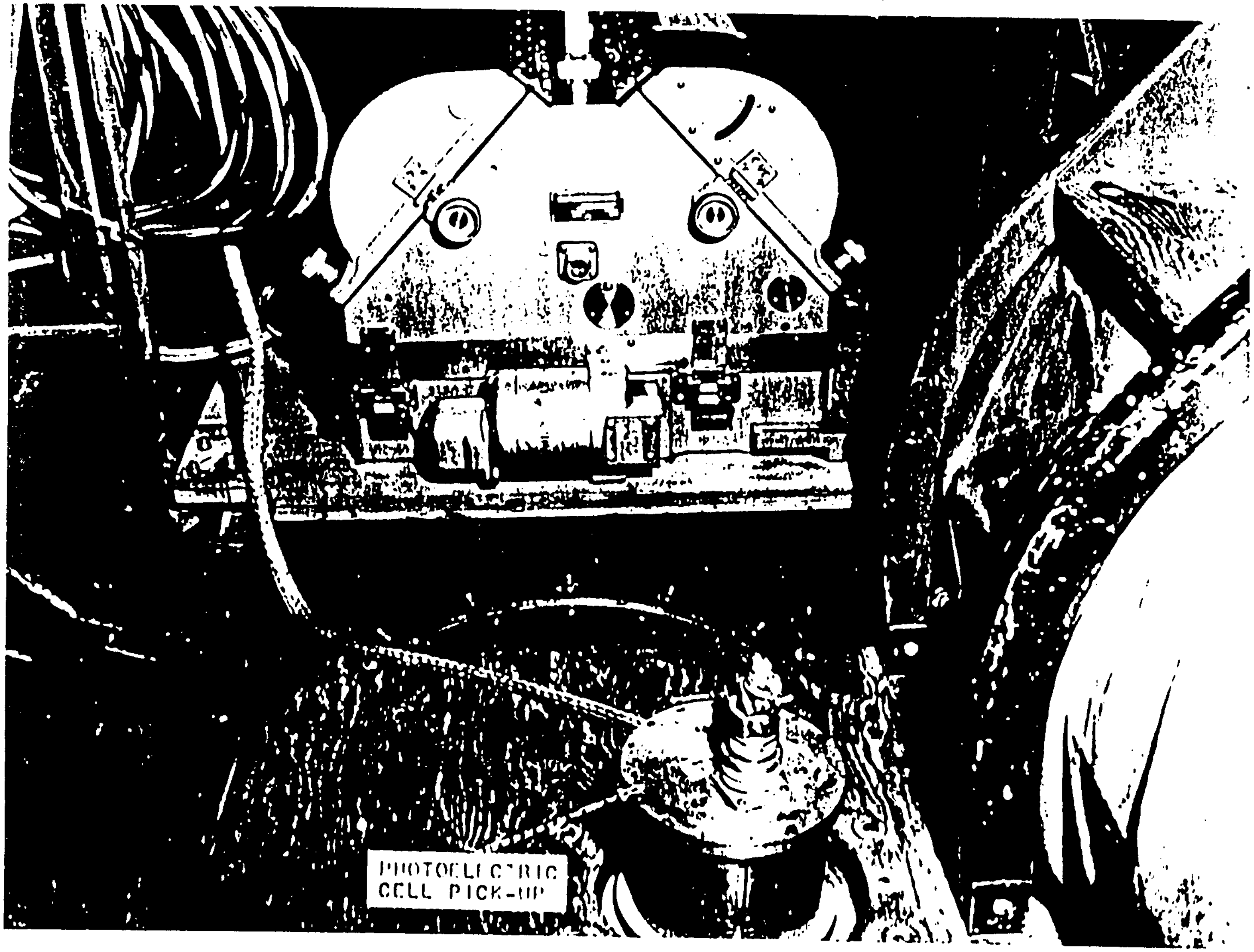

Fig. 1.16—Buster-Jangle B-50 No. 7169, IBDA T-11 camera installation in camera well.

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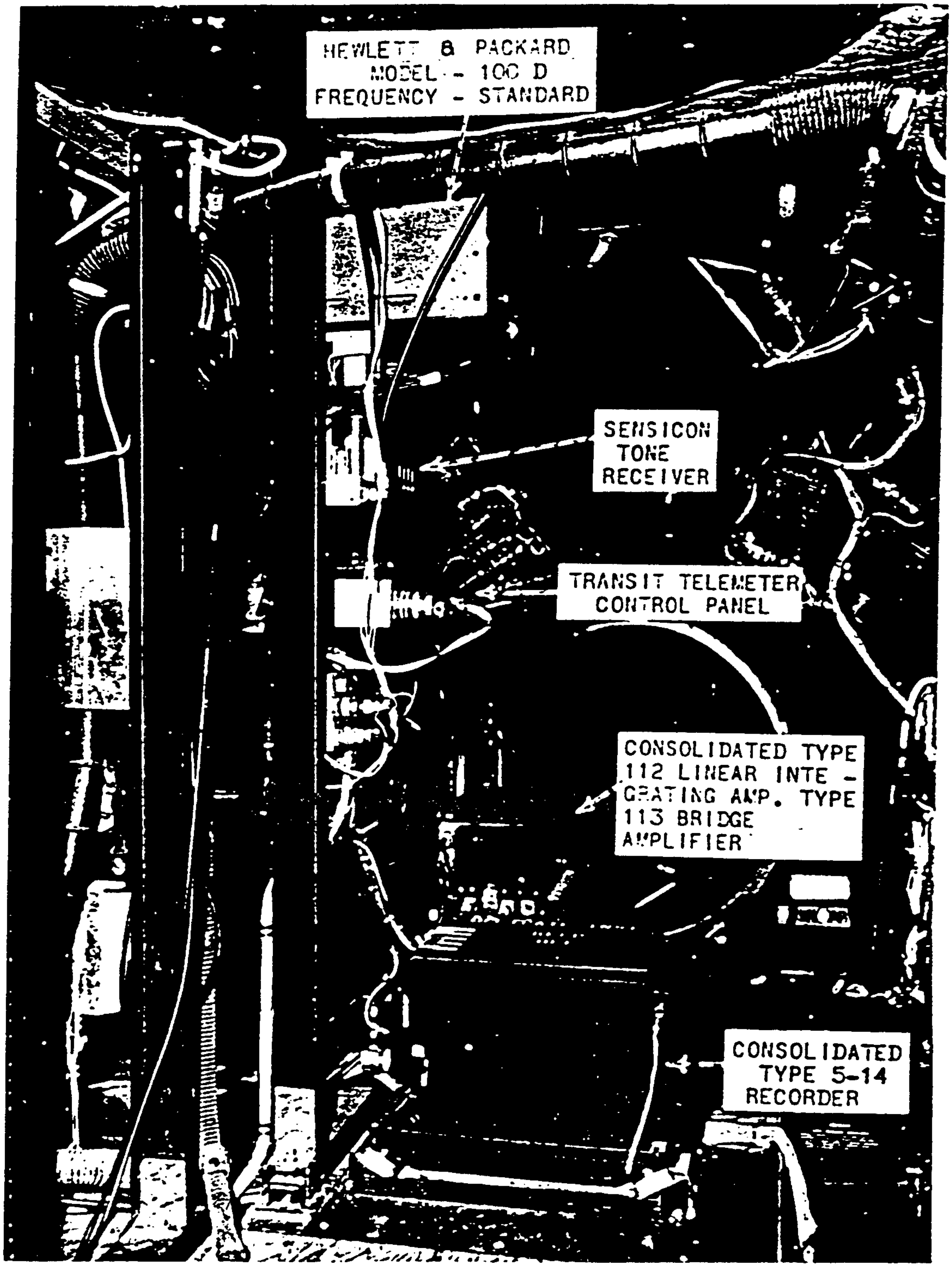

Fig. 1.17—Buster-Jangle B-50 No. 7169, recording equipment.

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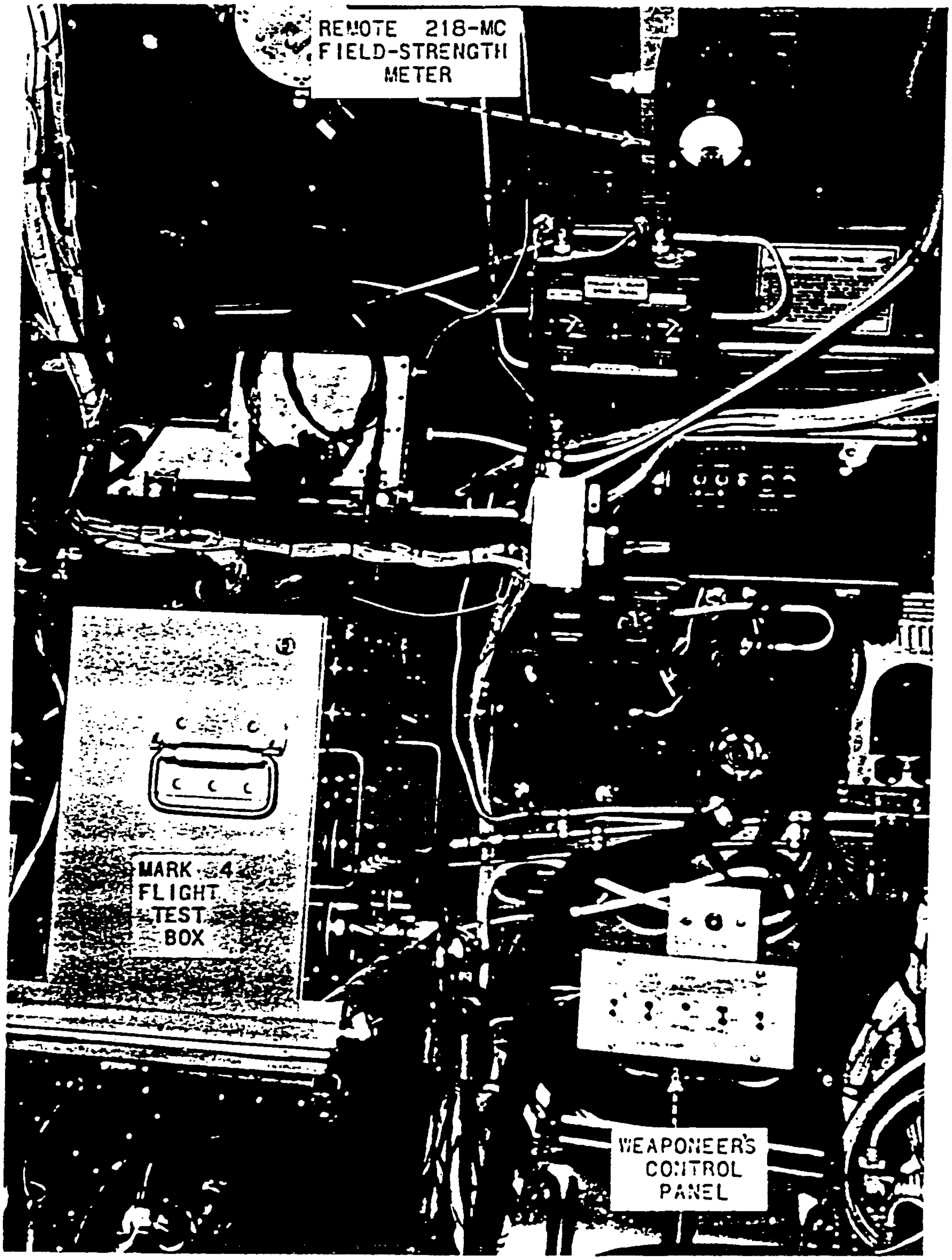

Fig. 1.18—Buster-Jangle B-50 No. 7169, weaponeer's position.

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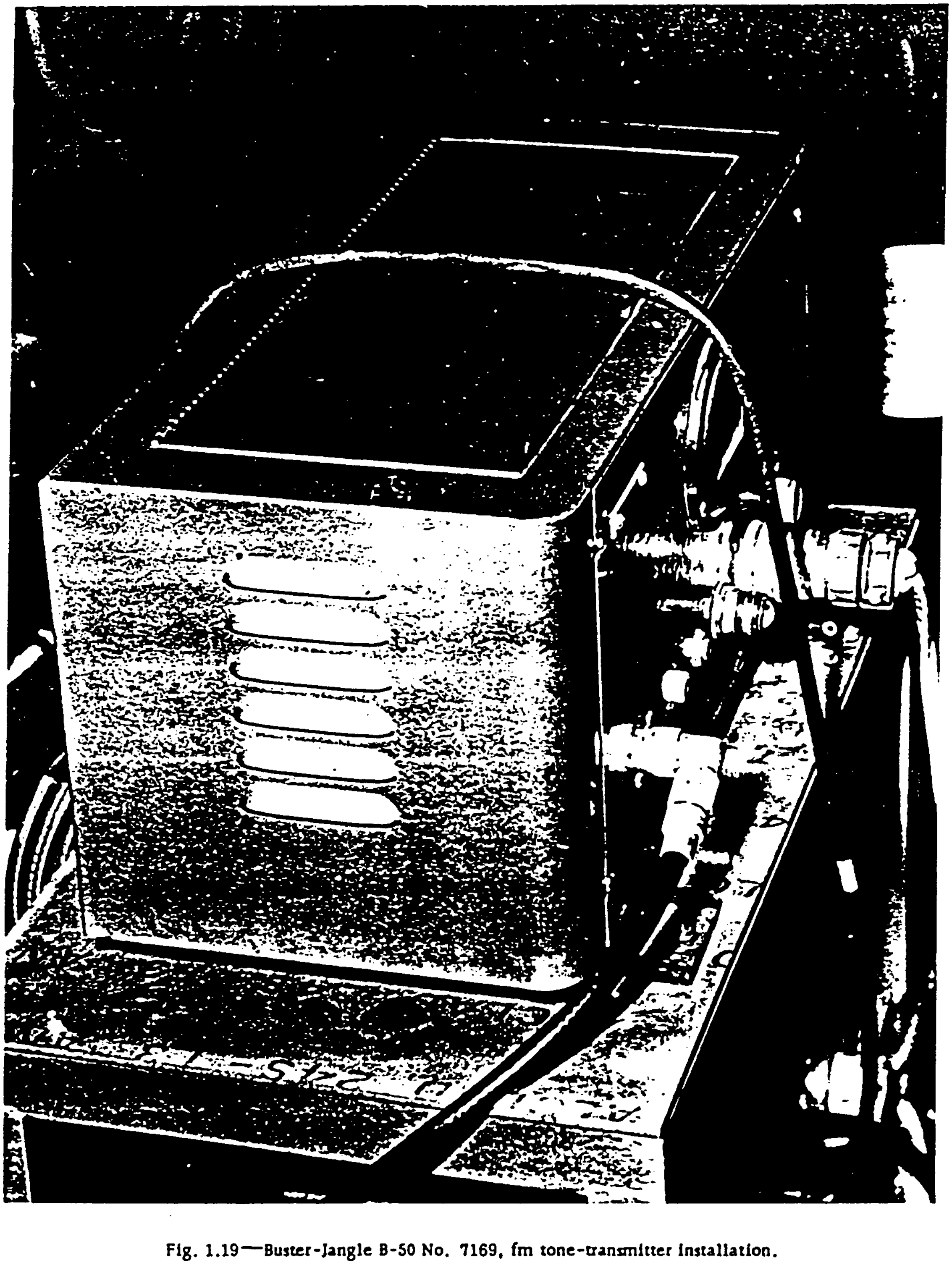

Fig. 1.19—Buster-Jangle B-50 No. 7169, fm tone-transmitter installation.

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transmitter could be relayed to the ground receiving stations, a radio-frequency (rf) signal-strength meter was installed in the aircraft at the weaponeer's position (Fig. 1.18). Previously several test drops were made by the 4925th Test Group (Atomic) for Sandia Corporation at the Salton Sea Test Base, with no signal being received at the ground stations prior to release; however, shortly after release the signal was received at the ground stations, and a record was obtained. Owing to the nature of the Buster drops, prior knowledge that the telemeter transmitter was operating properly was essential to the ground-station operation. The bomb could be released whether or not the signal was being heard at the ground stations at the time of release, and total time of fall would be available for tuning in the signal at the ground stations. This plan was successful during Operation Buster, and rf signal-strength meters have been installed in all bomber-type drop aircraft for use in the Salton Sea telemetered test-drop program.

1.3.5 Release Tone

Two frequency-modulation (fm) tone transmitters were installed. These transmitters indicated bomb release by having a 1000-cycle tone cut off by the U-1 release-hook actuation. This tone actuated ground instrumentation. Figure 1.19 shows the tone-transmitter installation.

1.4 CONCLUSIONS ON THE OPERATION OF THE BHANGMETER

The airborne Bhangmeter used on these tests provides a satisfactory method of determining yield. However, certain refinements should be accomplished in order to make this instrument operationally suitable for Air Force use in aircraft. For airborne tactical use, the following faults are found:

1. Batteries are the present source of power. Low operating temperatures and difficulties of storage make this type of power unsuitable.
2. Film development under low operating temperatures could be unsatisfactory.
3. Initial trace rise of the recorded light curve is difficult to read.
4. Changing the sweep duration requires soldering resistors in the electronic circuitry.

1.5 RECOMMENDATIONS FOR MODIFICATION OF THE BHANGMETER

It is recommended that consideration be given to developing a tactical airborne yield-measuring device from the EG&G airborne Bhangmeter. To make this Bhangmeter suitable for airborne tactical use, the following modifications are recommended:

1. Substitute for the battery pack a regulated power supply utilizing aircraft 115-volt 400-cycle power. This supply should be as small as possible, with little or no increase in weight or volume over the present supply.
2. Add a heating system in order to ensure optimum development of pictures under conditions of extreme cold.
3. Add a delay in the light trace to move over the initial rise on the scope tube. This would make the interpretation of the time-to-light minimum easier.
4. Locate a wafer switch on the front panel to change sweep duration for different sized bombs. For small bombs a higher frequency might mean an increase in the accuracy to which the light minimum could be interpreted.
5. The Bhangmeter should be built to conform as close as is possible to JAN specifications for airborne electronic equipment.

CHAPTER 2

DETAILED EQUIPMENT DESCRIPTION AND TEST PROCEDURE

2.1 EG&G DISK CAMERA

The disk camera was installed in the lower forward-turret well in a Type A-11A mount. The trail angle was set as close as possible on the mount to ensure the direct camera view of the fireball. It will be noted from Fig. 1.1 that the camera is round and has three lenses located at different distances from the center, 120° apart. Inside the camera is a glass plate that is rotated at 20 rps. This glass plate is coated with a light-sensitive emulsion. The emulsion speed is daylight Weston Six on the coated disk. It can be seen that exposure of the rotating disk to a fireball by the three lenses will cause three concentric streaks to be registered on the emulsion. The streaks will start as pin points and will expand until capped by the shutters.

In actual operation the rotation of the disk was started by a manual switch located on the weaponeer's control panel (see Fig. 1.18). This was accomplished 15 sec prior to detonation. Upon release a B-7 intervalometer was activated, and this opened the camera shutters 1 sec prior to detonation. At detonation the Blue Box fiducial Type A-1 located in the right-scanner's blister (see Fig. 1.4) received the bomb light and sent a pulse to the 200-cps gated marker and the trigger box (see Fig. 1.6). The gated marker placed zero time on the edge of the disk and also 200-cps velocity marks. The trigger box that received a detonation signal from the Blue Box delayed this signal for 30 to 35 msec and then closed the shutters. Figure 1.3 shows the disk camera installed in the lower forward-turret well.

2.2 EG&G BHANGMETERS

The Bhangmeter is a self-contained cathode-ray oscillograph that traces the light curve of a bomb in a pulse-modulated 1000-cps trace. The trace is recorded by a Land Polaroid camera, which allows the operator to obtain a developed print of the trace in 1 min. The time to minimum of the light curve is easily obtained by counting the 1000-cycle dots making up the curve. Figures 1.7 to 1.9 show the Bhangmeter. The lower half contains the batteries, and the upper part contains the electronic components. Note the photoelectric-cell pickup head. During the tests the head was mounted in the left-scanner's blister, with direct observation of the detonation. Figure 1.10 shows the Bhangmeters installed in the left-scanner's position; Figs. 1.11 and 1.12 show the photoelectric-pickup heads in position in the left blister. The total weight of the Bhangmeter is 25 lb, and its dimensions are approximately 6 by 12 by 16 in.

Check out of the Bhangmeters was accomplished the day prior to the drop. First the sweep circuit was tested by pressing the trigger-test button and developing the resulting print (Fig. 1.13a). Then a print was made with both a trigger-test trace and the light trace of a Type SM photoflash bulb fired 18 in. from the photocell-pickup head (Fig. 1.13b). This tested the complete Bhangmeter circuit including the photocell operation.

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In-flight procedure consisted in turning the Bhangmeters on 10 min prior to bomb release. At −4 min the sweep circuits were trigger tested, and the pictures were developed (see Fig. 1.13a). At −3 min the traces were again triggered. Bomb detonation was recorded above this reference trace as shown for the Buste[redacted]drop in Figs. 1.13c and d.

Difficulty was experienced with the first nuclear drop because the bomb-light trace did not appear to have a minimum. A grid consisting of lines parallel to the no-signal trace at the bottom of the picture was used in an attempt to locate the minimum. When this grid was placed over the picture, the bomb-light trace did not appear to rise once the first light cycle was complete. No minimum was apparent. After some investigation it was found that, with different constant input voltages to the photohead, the slope of the triggered trace would decrease as the voltage input was increased. This was due to an RC discharge characteristic of the Bhangmeter circuitry. An overlay grid that could be used to determine the minimum of a light curve similar to those of Figs. 1.13c and d was therefore necessary.

The improved overlay grid was made by triggering the trace with different constant input voltages to the photohead. Figures 1.14a and b show the resulting pictures when d-c input voltages of 0, 90, 135, 180, and 225 were used to trigger the circuit. From these pictures an overlay grid was made. This grid was placed over the recorded trace so that the no-signal trace on the grid coincided with the reference trace on the recorded Bhangmeter light trace. The static voltage line on the grid nearest the light trace was used to determine the minimum. In the case of Buste[redacted](see Figs. 1.13c and d) the curve actually does have a minimum at 6.0 msec. Table 2.1 gives the Bhangmeter time-to-light-minimum results of all Operation Buster airdrops. These results were obtained by two Bhangmeters located in the drop aircraft. Three additional Bhangmeters located at the ground Command Post 11 miles distant recorded identical times to minimum.

Table 2.1 — BHANGMETER TIME-TO-LIGHT MINIMUM FOR BUSTER AIRDROPS

Drop	Time to minimum, msec	Fig. No.
B	6.0	1.13c,d
C	12.5	1.14c,d
D	15.5	2.1a,b
E	20.0	2.1c,d

It should be noted that Fig. 2.1a shows a lack of development undoubtedly due to a camera temperature lower than that existing during the other tests.

As the bomb yield increases, the time to minimum increases. This necessitated increasing the number of millisecond marks in the trace. This was accomplished prior to the second drop, and it will be noted that in Figs. 1.14c and d there is an increase to approximately 30 or 40 msec for the trace. The largest yield was estimated to have 17.5 msec to minimum, and therefore this one change was adequate.

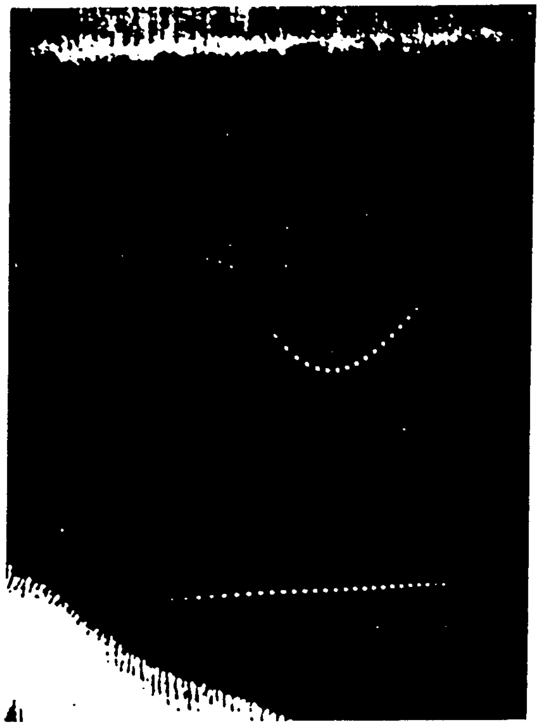
2.3 TIMES FROM RELEASE TO DETONATION TO SHOCK-WAVE ARRIVALS

A Consolidated Type 5-14 multichannel recording oscilloscope was used to record the necessary indications in order to ascertain accurate times from release to detonation to shock-wave arrivals. Consolidated Type 112 linear integrating amplifiers and a Consolidated Type 113 bridge amplifier were associated with the recorder. Two standard frequencies of 10 and 100 cps were put into separate recording channels from a Packard & Hewlett Co. model 100D frequency standard.

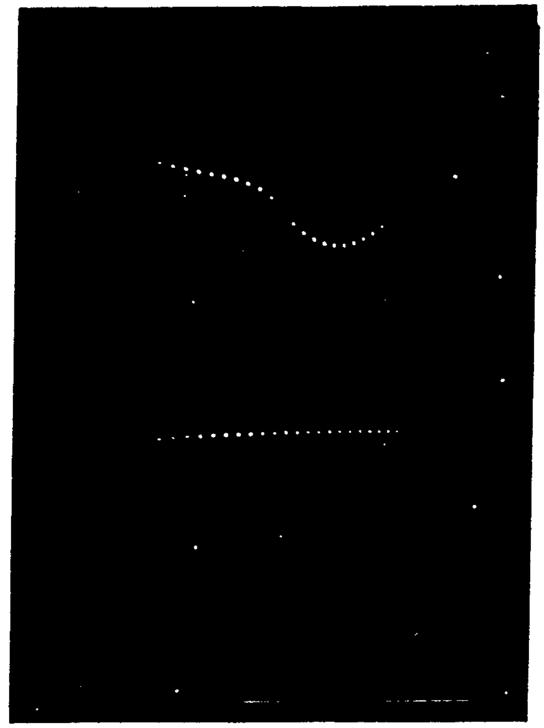
The first event recorded was the bomb release. This was accomplished by a microswitch actuated on the operation of the U-1 release. This was the beginning of the sequence timing and was zero time.

[redacted]

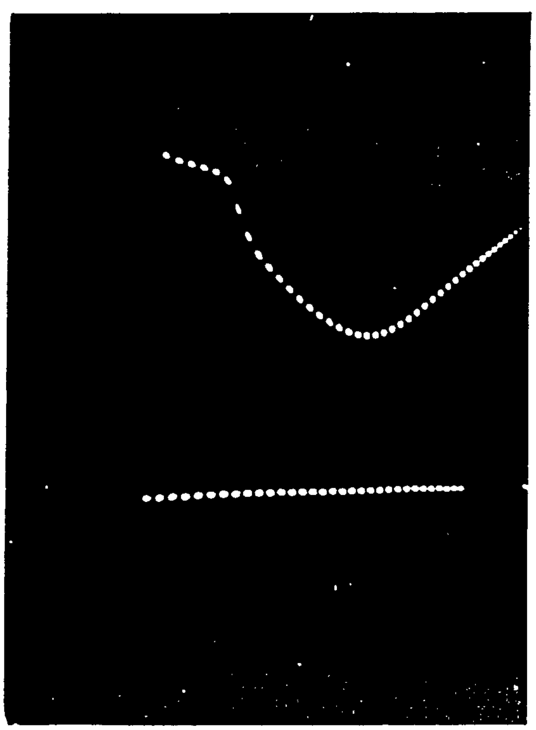
[redacted]



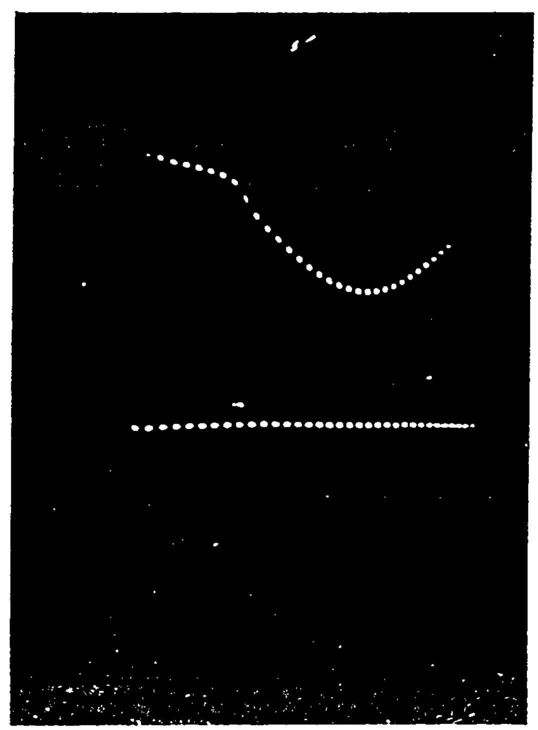
(a)



(b)



(c)



(d)

Fig. 2.1—Buster Bhangmeter results. (a) Buster [redacted] Bhangmeter 1 curve. (b) Buster [redacted] Bhangmeter 2 curve. (c) Buster [redacted] Bhangmeter 1 curve. (d) Buster [redacted] Bhangmeter 2 curve.

[redacted]

[redacted]

The second event was bomb detonation. This signal was received from the pulse output of an EG&G Blue Box fiducial Type A-1 located at the left-scanner's position (see Figs. 1.11 and 1.12). The recorded pulse was obtained from the cathode of a thyratron, and the system delay was less than 35 msec. The total time to this event is the time of fall.

The next events were the shock arrivals from the detonation. Three Wiancko blast gauges, Type 3 PAD10-S, were located on the underside of the aircraft just aft of the rear bomb bay. Two of the gauges fed separate channels on the recorder. The signal from the third gauge went through an amplifier to a light on the photopanel as an auxiliary method of recording shock-wave arrivals.

A Type F-1A airspeed indicator was calibrated for pressures of 0.25, 0.5, and 0.75 psi in terms of miles per hour. The calibration of the blast gauges was accomplished by using the calibrated F-1A indicator to indicate applied pressure to the gauges. These calibrated pressures gave a measured deflection on the blast channels of the Consolidated recorder as given in Table 2.2. The accuracy of the blast indications is within ±20 per cent.

Table 2.2 — PRESSURE DEFLECTION ON BLAST CHANNELS

Shot	Recorder channel, blast No.	Calibrating pressure, psi	Galvanometer deflection, in.
B	1	0.25	0.85
	2	0.5	0.85
C	1	0.5	0.85
	2	0.75	0.85
D	1	0.5	0.85
	2	0.75	0.85
E	1	0.5	0.85
	2	0.75	0.85

The times recorded and the overpressures in pounds per square inch of shock waves are listed by items 34 to 43 of Table 3.1. The shock-wave-pressure recordings are listed for the two individual blast-gauge channels. All times given in items 34 to 40 of Table 3.1 are given with release as zero time. To determine time between shock waves, the necessary subtraction must be made.

Copies of the original record have been made, and the release, detonation, and shock-wave indications are shown in the figures listed in Table 2.3.

Table 2.3 — LIST OF FIGURES SHOWING RELEASE, DETONATION, AND SHOCK-WAVE INDICATIONS

Shot	Release indication, Fig. No.	Detonation indication, Fig. No.	Shock wave, Fig. No.
B	2.2	2.3	2.4
C	2.5	2.6	2.7
D	2.8	2.9	2.10, 2.11
E	2.12	2.13	2.14, 2.15

2.4 RELEASE-TONE EQUIPMENT

Two fm tone transmitters (see Fig. 1.19) were carried in the drop aircraft. These transmitters operated on 150.66 and 136.08 Mc and were known as high tone and low tone. The

(Text continues on page 50.)

[redacted]

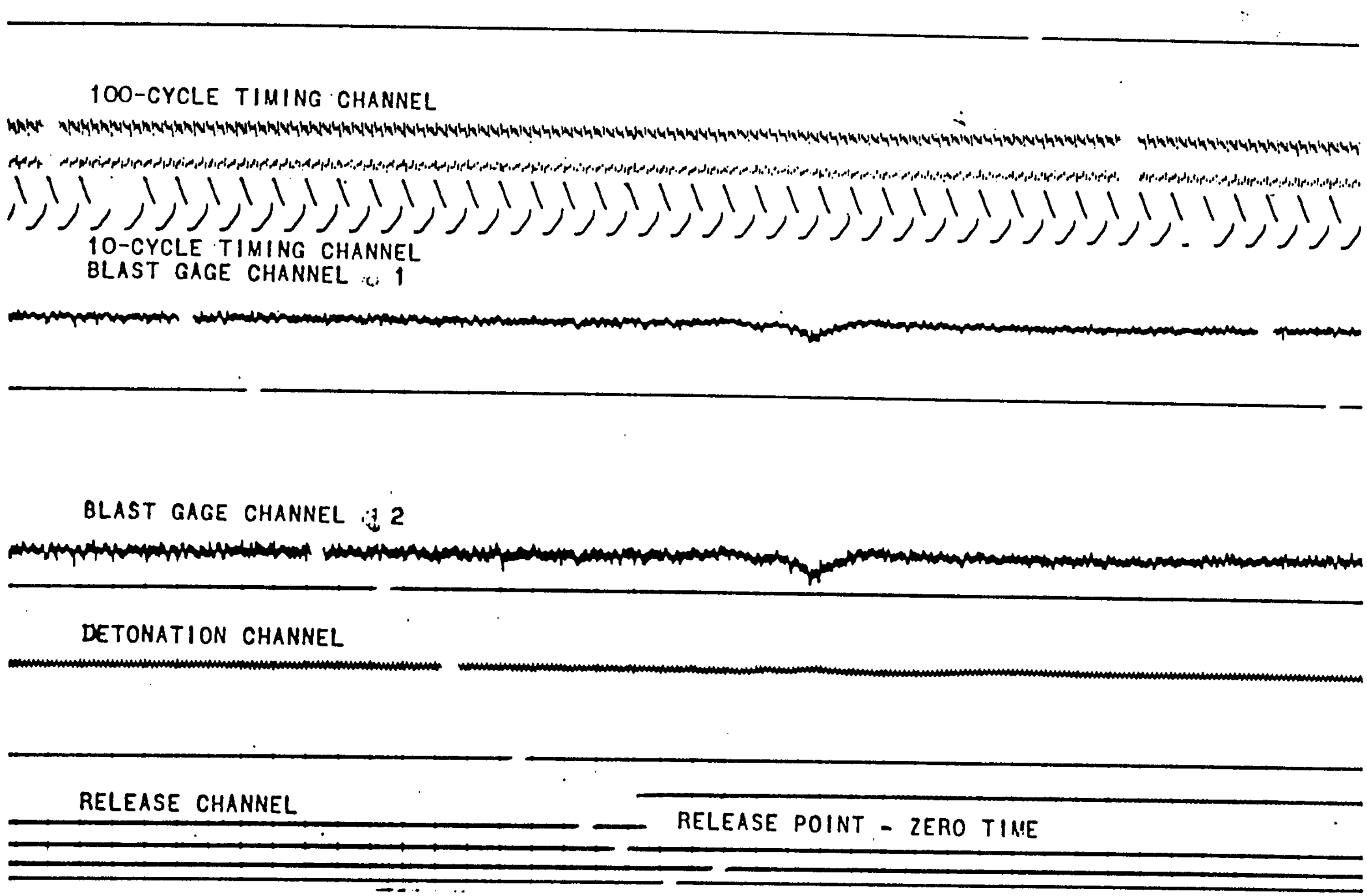


Fig. 2.2—Buster-[redacted] release.

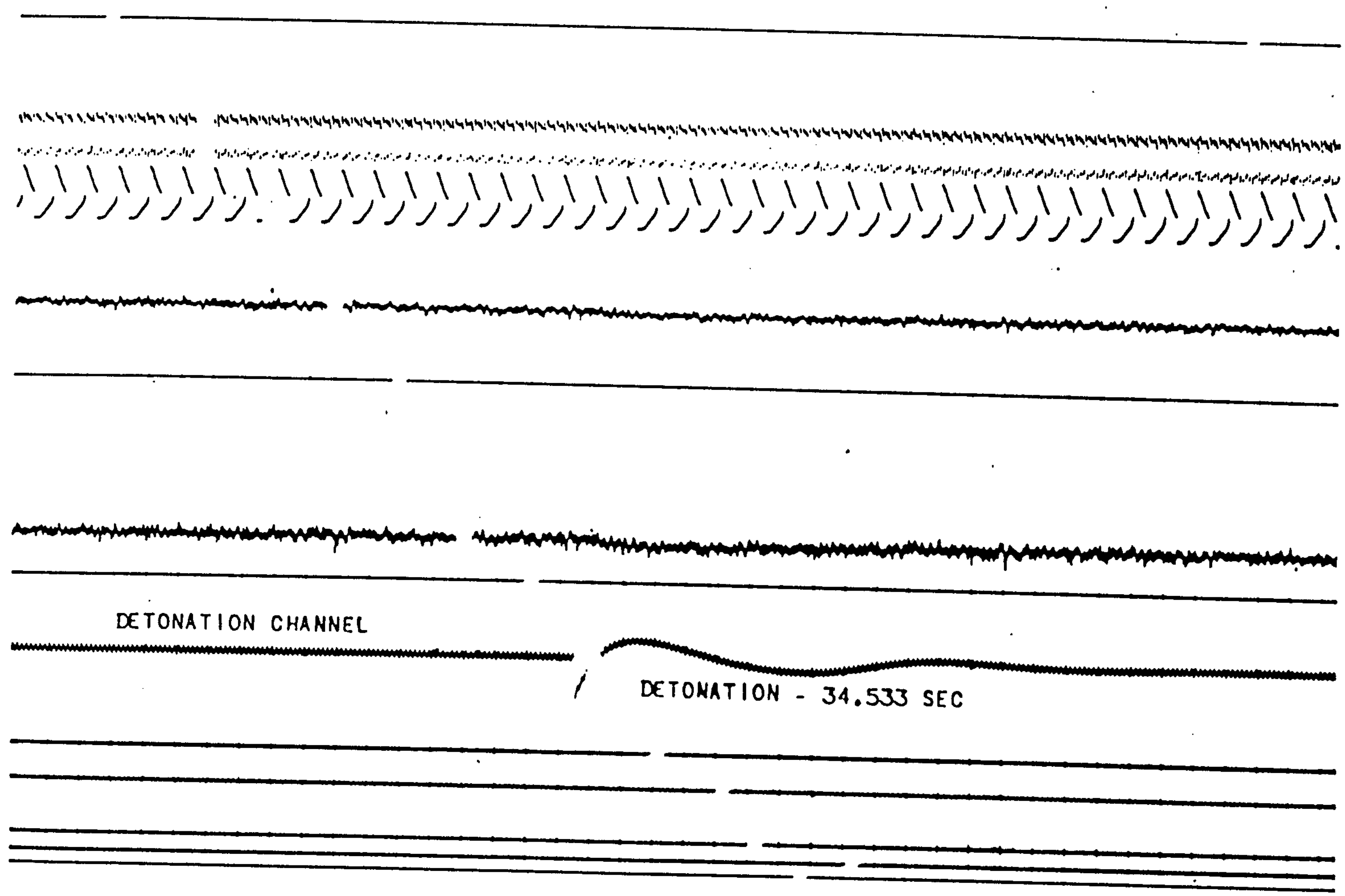


Fig. 2.3—Buster [redacted] detonation.

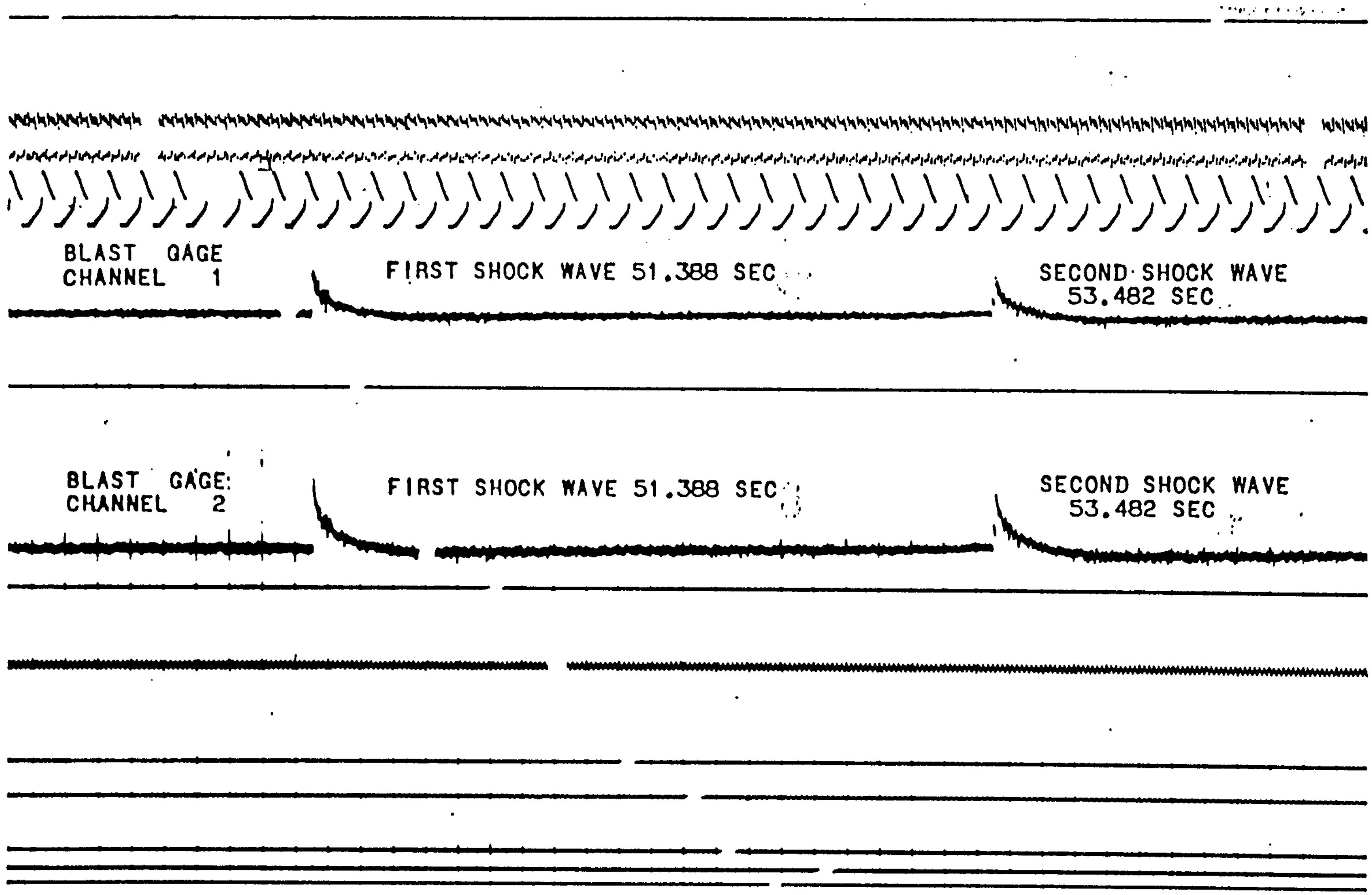


Fig. 2.4—Buste[redacted]shock waves.

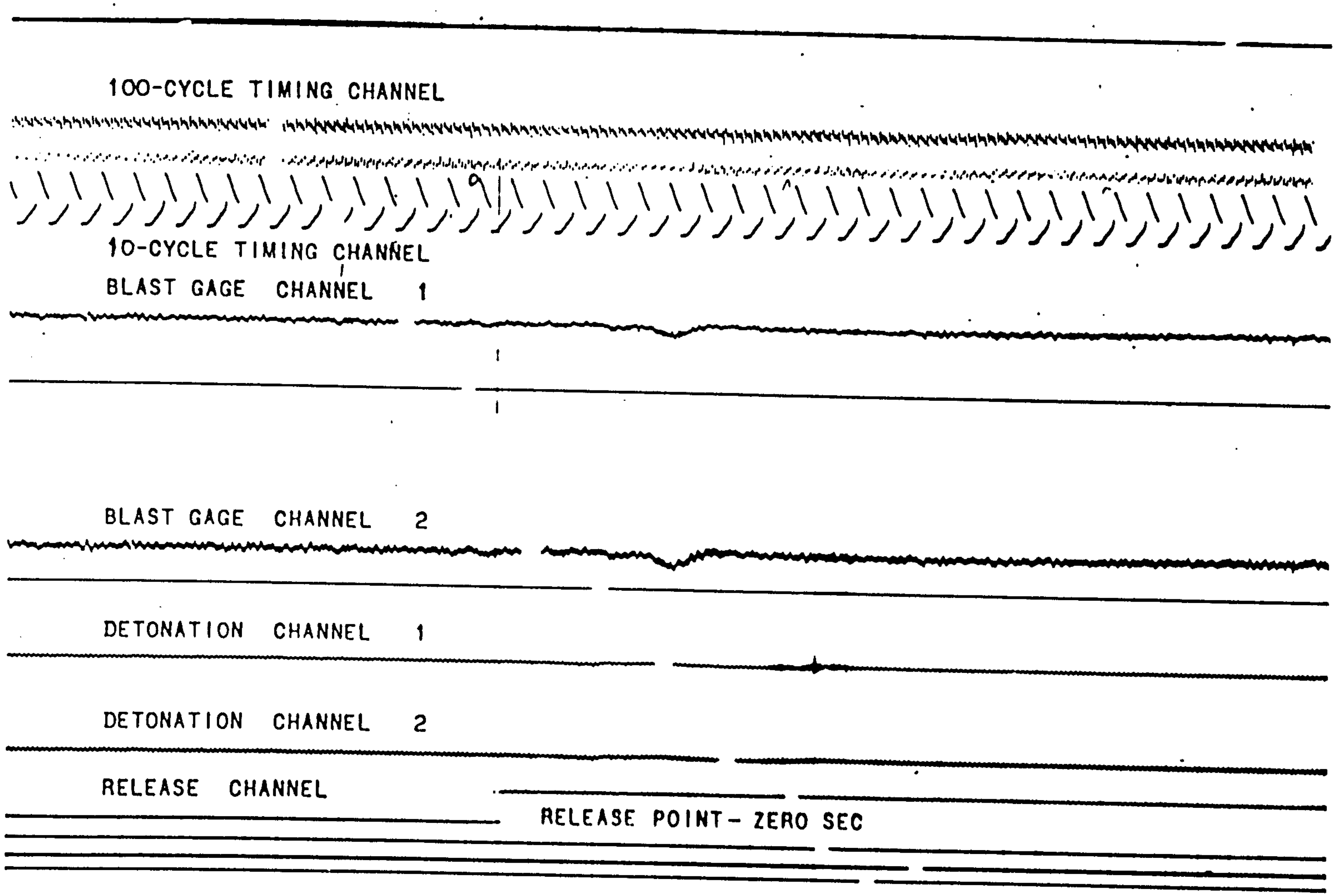


Fig. 2.5—Buster [redacted] release.

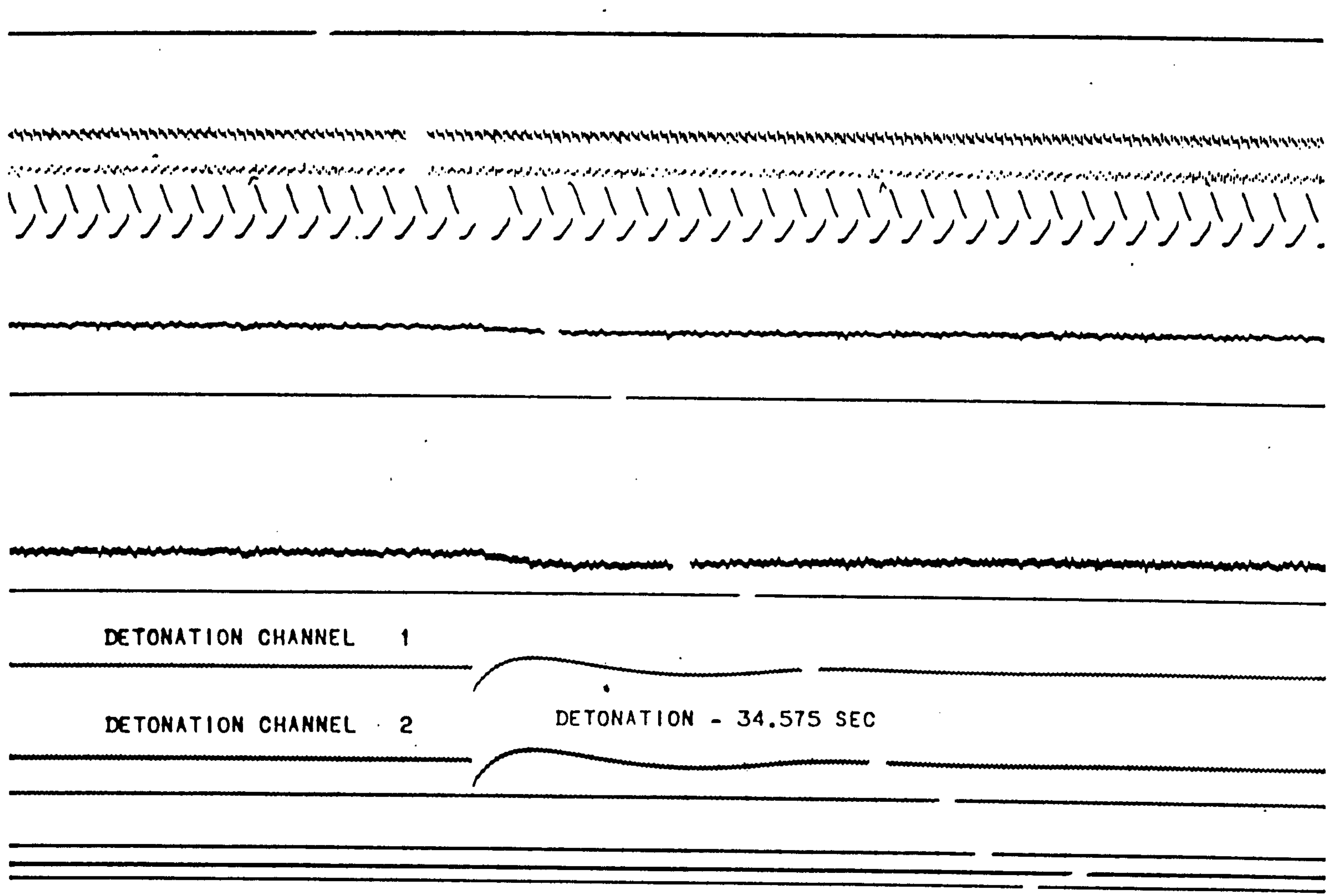


Fig. 2.6—Buster [redacted] detonation.

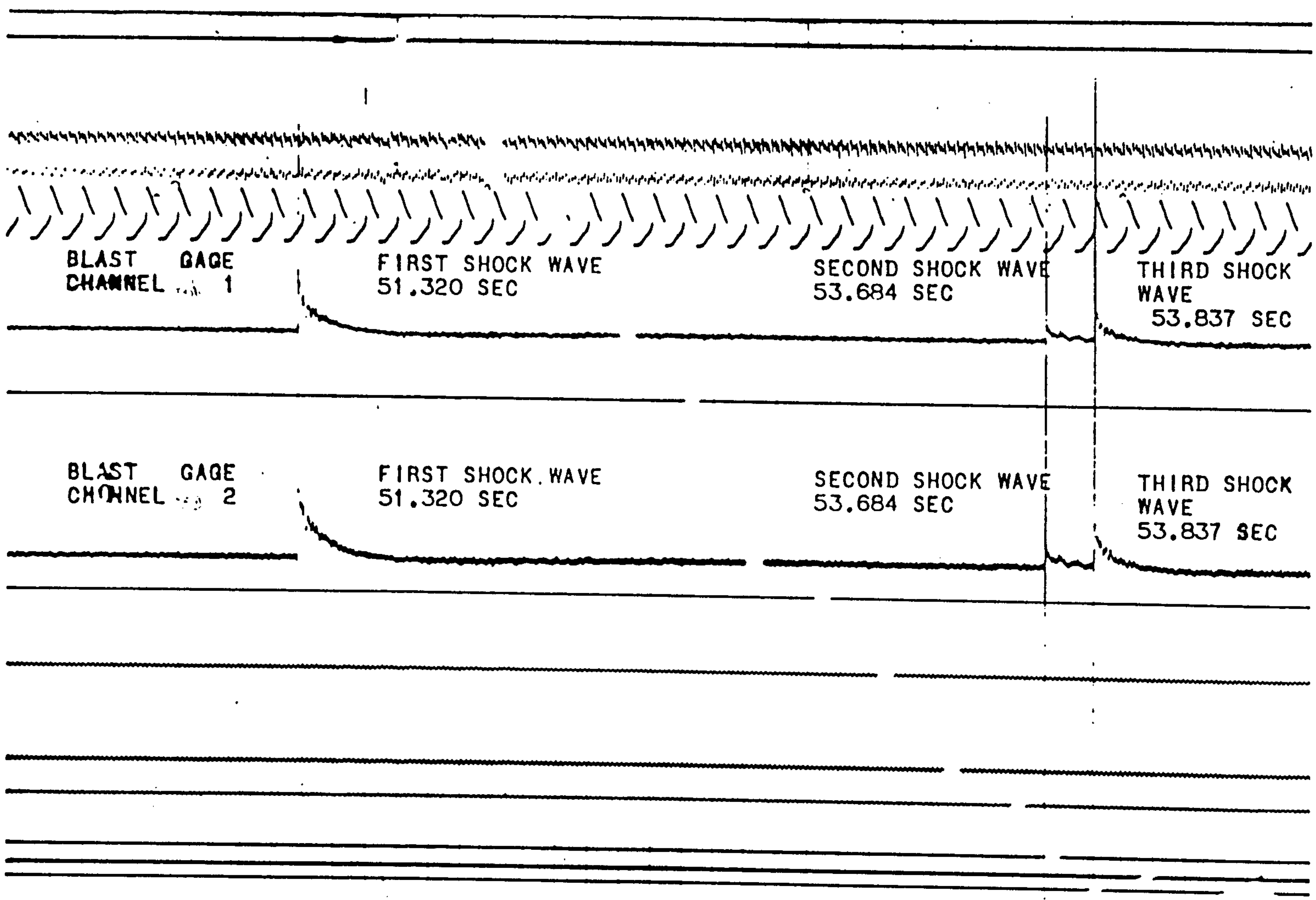


Fig. 2.7—Buster [redacted] shock waves.

[redacted]

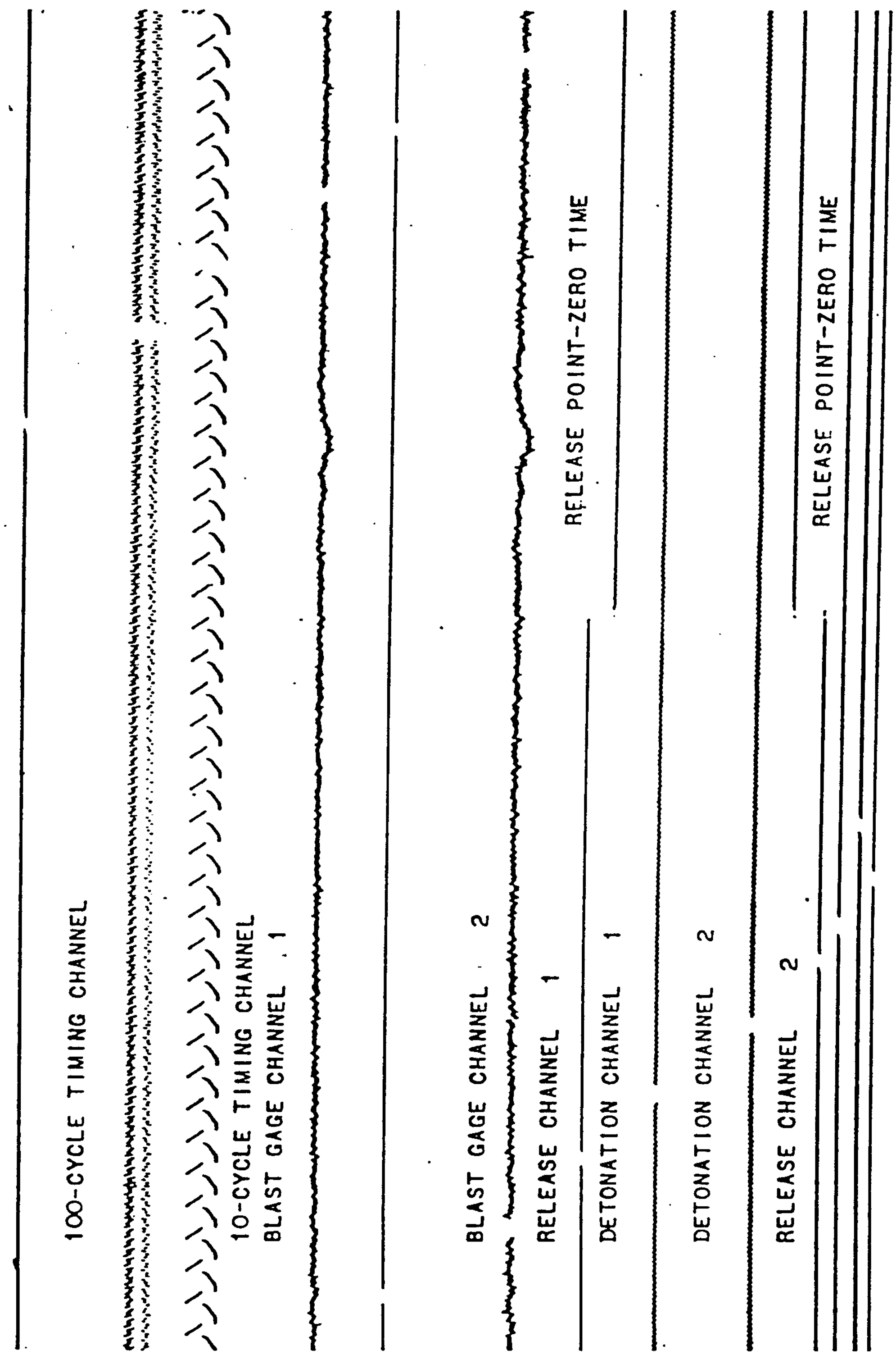


Fig. 2.8—Buster [redacted] release.

[redacted]

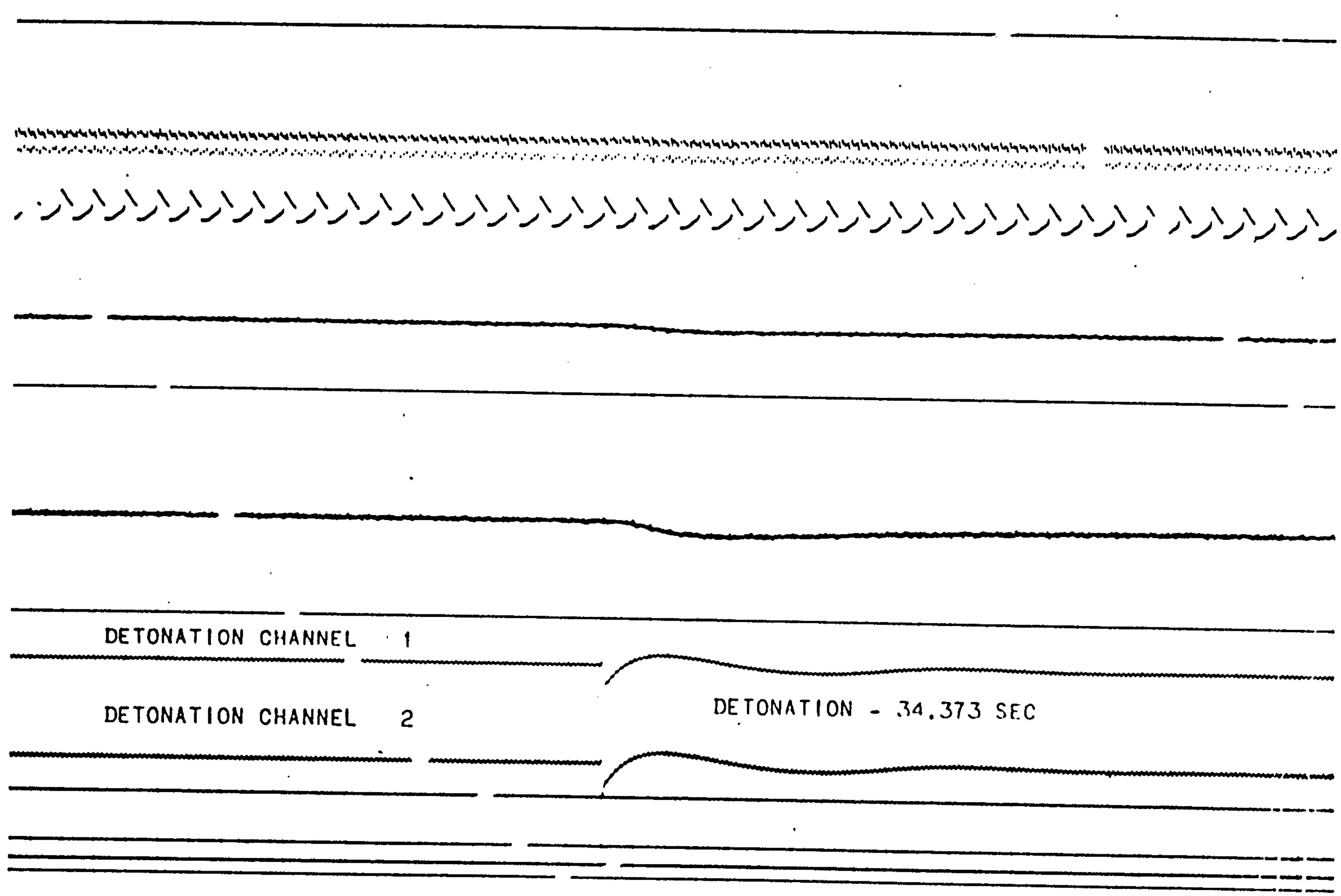


Fig. 2.9—Buster [redacted] detonation.

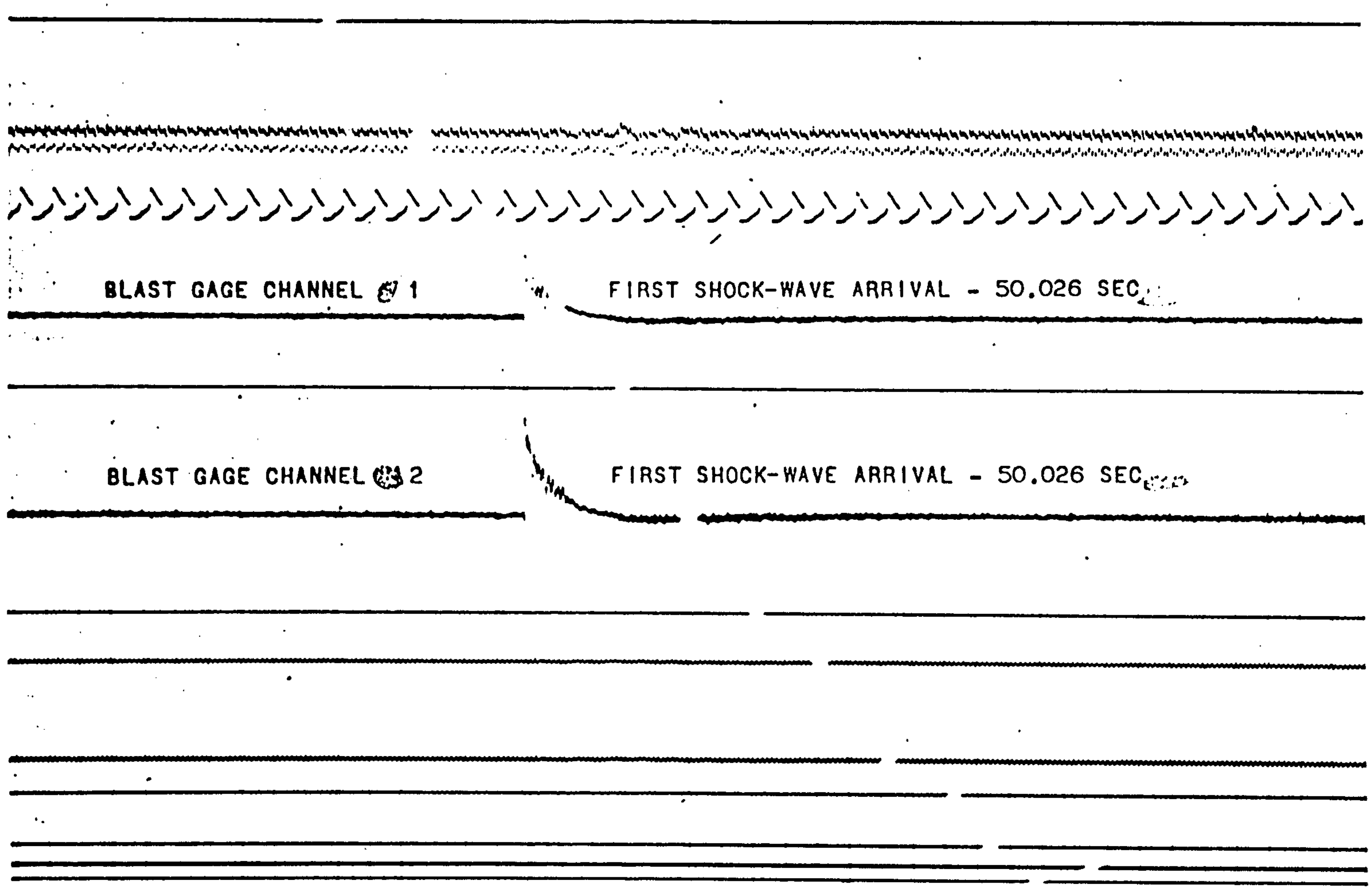


Fig. 2.10—Buster [redacted] shock wave.

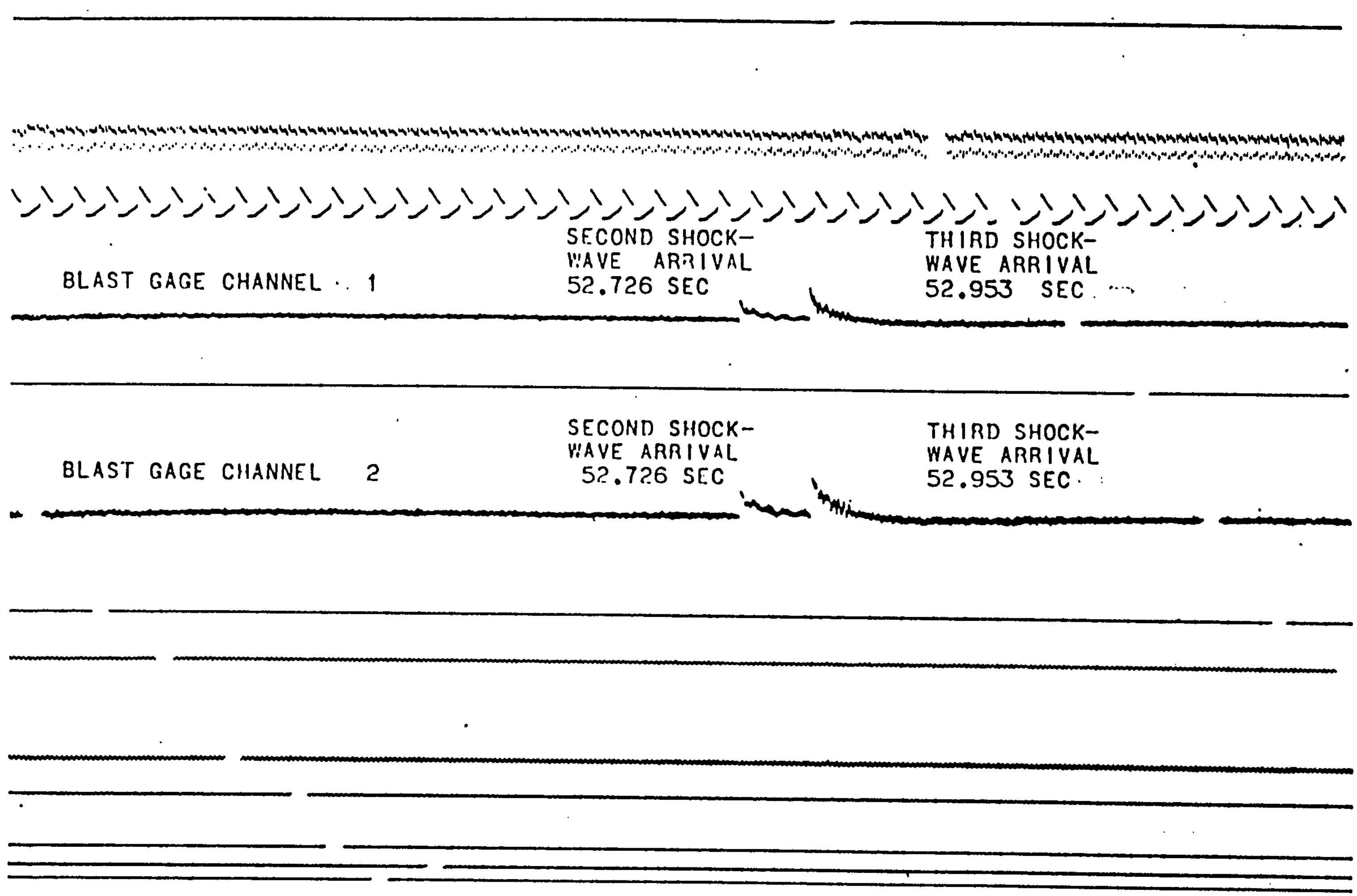


Fig. 2.11—Buster [redacted] shock waves.

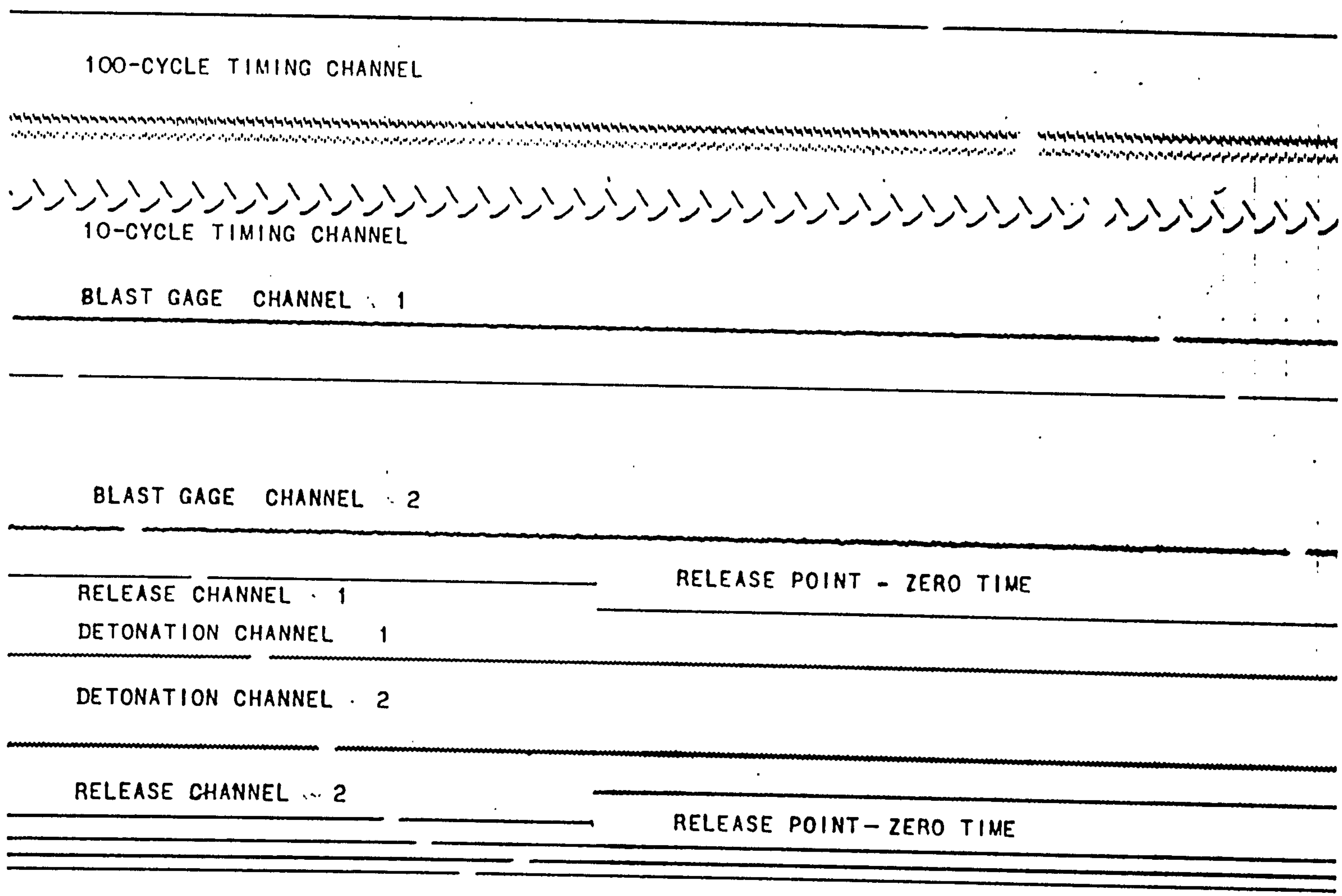


Fig. 2.12—Buster [redacted] release.

[redacted]

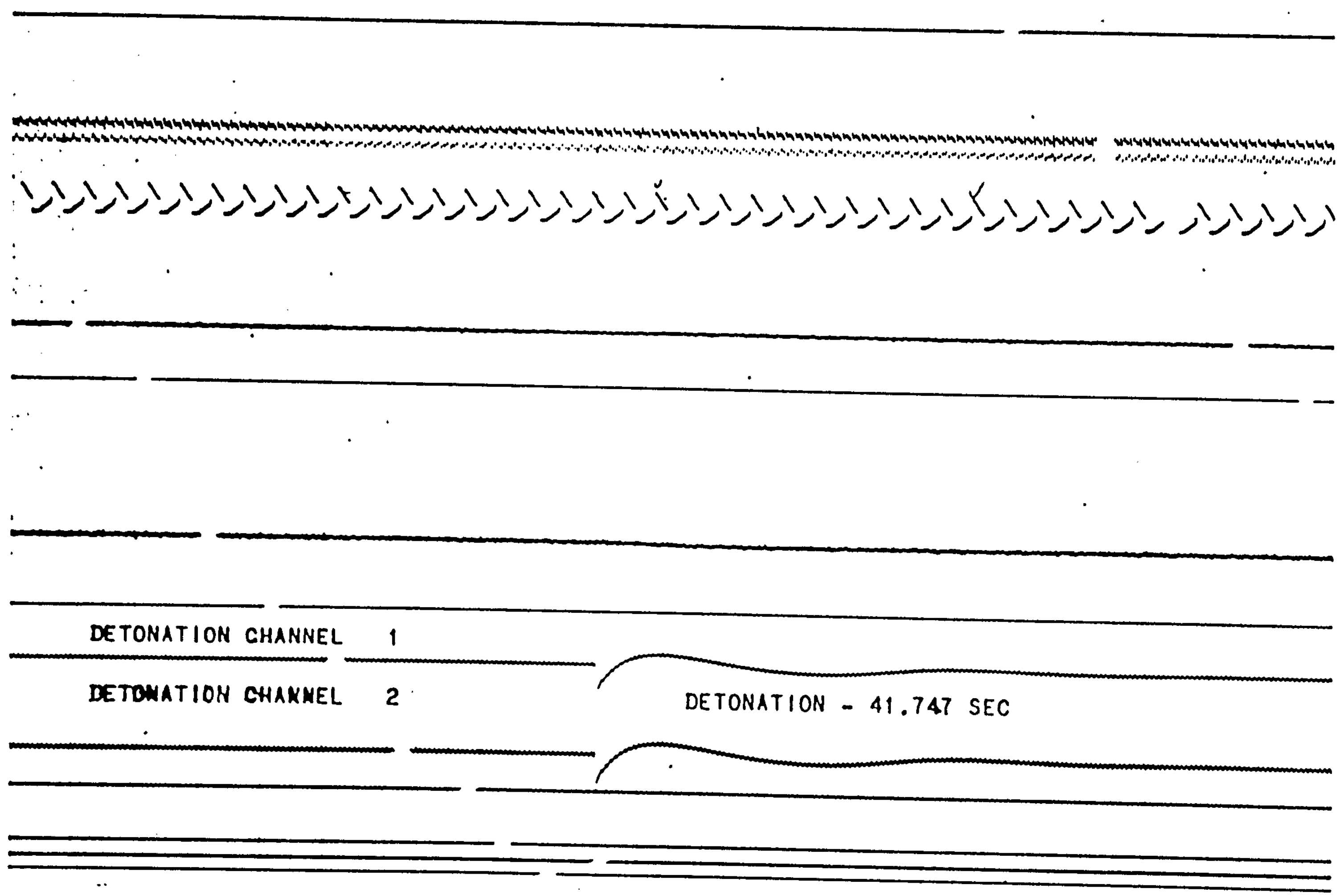


Fig. 2.13—Buster [redacted] detonation.

[redacted]

[redacted]

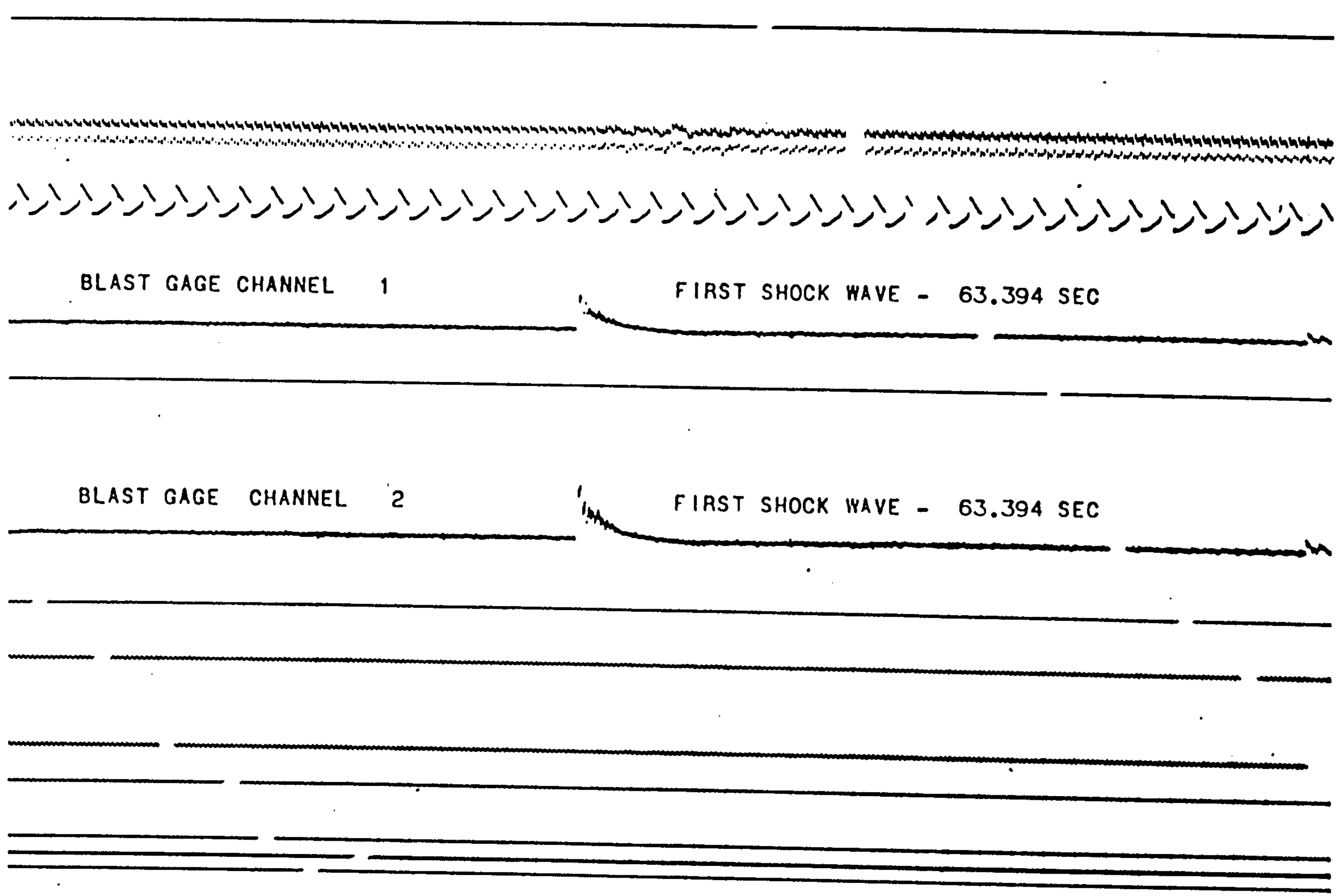


Fig. 2.14—Buster [redacted] shock wave.

[redacted]

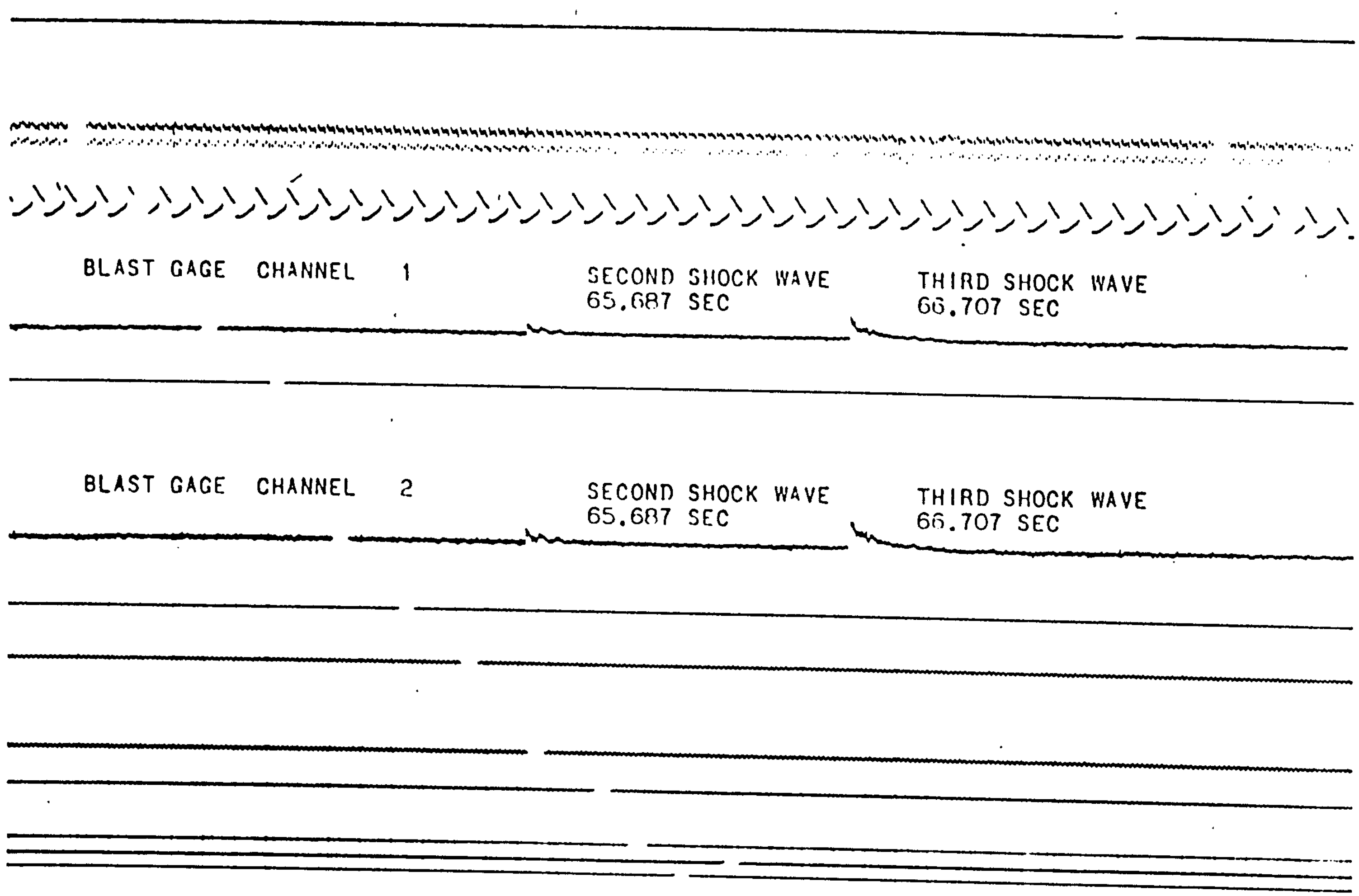


Fig. 2.15—Buster [redacted] shock waves.

[redacted]

CHAPTER 3

SUMMARY OF TEST DATA AND RESULTS

3.1 GENERAL DISCUSSION

Table 3.1 contains a consolidation of all information gathered by instrumentation aboard B-50 No. 7169. The information necessary to correlate the results of the data gathered is also contained in this table.

It should be noted that the [redacted] drop was made from B-45 No. 001. The instrumentation was carried in B-50 No. 7169; therefore the blast results noted in the chart and the times other than time of fall are not directly applicable to the carrier aircraft for this particular drop. The slant ranges given for the last drop are for the B-45 and, therefore, do not mean much for blast-data correlation. As well as could be determined, the B-50 was 500 ft higher than, and 500 ft behind, the B-45 during the bomb run.

The information regarding climatological conditions requested by the Strategic Air Command (SAC) are also contained in Table 3.1. Reference is made to the Air Weather Service Buster-Jangle reports WT-342 and 361 for additional climatological information.

3.2 EXPLANATION OF TABLE 3.1

An explanation of the items of information recorded in Table 3.1 follows for data where a question might arise. This explanation includes the methods of gathering the data and the accuracies involved, when available.

Item 4 is a capsule designation identifying the particular drop. LASL should be consulted if more information is desired.

Item 6 gives absolute altitude above the target as flown by the drop aircraft. This information was gathered by an SCR-718 radar altimeter and is accurate to ±100 ft.

Item 14 is the release time as it was recorded by a camera operating at 8 frames/sec from a clock in the photopanel. This clock was not set accurately to WWV but did give elapsed time of occurrences.

Item 15 is the predicted time of fall as taken from the bombing tables for the [redacted] The [redacted] predicted time of fall is from special Sandia Corporation ballistic tables. All time-of-fall predictions are to detonation.

Item 17 gives the trail figures for each drop. The top figure gives the actual trail as given in the bombing tables; the bottom figure gives the trail with the Q factor incorporated.

Item 18 states the Q factor used for each drop. This was computed both on the ground and in the aircraft during the dummy bomb runs.

Item 19 gives the disk speed used on the bomb sight.

[redacted]

[redacted]

Table 3.1 — CONSOLIDATION OF B-50 No. 7169 INSTRUMENTATION INFORMATION AND SUPPLEMENTAL DATA

Item	Shot B	Shot C	Shot D	Shot E
Bomb Identification				
1. Date	Oct. 28, 1951	Oct. 30, 1951	Nov. 1, 1951	Nov. 5, 1951
2. Type unit	[redacted]	[redacted]	[redacted]	[redacted]
3. Bomb No.	[redacted]	[redacted]	[redacted]	[redacted]
4. Capsule type	[redacted]	[redacted]	[redacted]	[redacted]
Drop-aircraft Information				
5. Drop aircraft	B-50 No. 7169	B-50 No. 7169	B-50 No. 7169	B-45 No. 001
6. Absolute altitude, ft	19,000	19,000	19,000	24,900
7. Pressure altitude, ft (29.92'')	22,095	22,300	22,150	27,385
8. Indicated air speed, mph	193	193	193	224
9. True air speed, mph	276	276	276	350
10. Ground speed, mph	238	293	222	317
11. Bomb track, deg	50	280	280	320
12. True course, deg	49	283	283	321
13. Free-air temp., °C	−13	−18		−24
14. Photopanel release	0717:36	0658:47		0829:54
15. Predicted time of fall, sec	34.6	34.6	34.3	41.8
16. Drop-angle tangent	0.595	0.740	0.534	0.650
17. Trail:				
Without Q factor	62.5	62.5	62.5	205.1
With Q factor	41.2	15.2	40.0	198.1
18. Q factor	2	5	2	1.2
19. Disk speed	155.6	161.4	157.0	116.92
Target Information				
20. Target elevation, MSL, ft	4190	4190	4190	4224
21. Target coordinates, Nevada Central Zone	N 850,424 E 688,684	N 850,424 E 688,684	N 850,424 E 688,684	N 583,124 E 687,502
22. Target coordinates,* geodetic positions†	37° 5′4.5″ 116° 1′11.0″	37° 5′4.5″ 116° 1′11.0″	37° 5′4.5″ 116° 1′11.0″	37° 5′31.2″ 116° 1′25.6″

[redacted]

[redacted]

Table 3.1 — (Continued)

Item	Shot B	Shot C	Shot D	Shot E
		Detonation Information		
23. Circular error, ft	141 ± 15	190 ± 15	67 ± 20	200 ± 15
24. Circular error, distances from target zero, ft	140′N, 14′W	162′N, 99′W	56′N, 36′E	54′S, 192′W
25. Photopanel detonation time, MST		0659:52		
26. Actual recorded detonation time, MST	0720:09.5	0700:30.6	0730:01.56	0829:58.17
27. Burst setting on radar fuse, ft	1050	1050	1350	1350
28. Measured burst above ground, ft	1118 ± 10	1132 ± 10	1417 ± 10	1314 ± 10
29. Measured burst above MSL, ft	5308 ± 10	5322 ± 10	5607 ± 10	5538 ± 10
		Effects Information		
30. Slant range to detonation, ft	17,896	17,872	17,595	24,078‡
31. Slant range at 1st shock, ft	19,066	19,409	18,504	27,888‡
32. Slant range at 2d shock, ft	19,322	19,827	18,797	28,472‡
33. Slant range at 3d shock, ft	None	19,855	18,823	28,741‡
34. Measured time of fall, sec	34.533	34.575	34.373	41.787
35. Time of 1st shock wave, sec	51.388	51.320	50.026	63.434‡
36. Time of 2d shock wave, sec	53.482	53.684	52.726	65.727‡
37. Time of 3d shock wave, sec	None	53.837	52.953	66.747‡
38. Time from detonation to 1st shock wave, sec	16.855	16.745	15.653	21.647‡
39. Time from detonation to 2d shock wave, sec	18.949	19.109	18.353	23.960‡
40. Time from detonation to 3d shock wave, sec	None	19.262	18.580	24.960‡
41. Pressure 1st shock wave, psi				
Blast gauge 1	0.34	0.37	0.44	0.73‡
Blast gauge 2	0.39	0.41	0.44	0.73‡

[redacted]

[redacted]

Table 3.1 — (Continued)

Item	Shot B	Shot C	Shot D	Shot E
42. Pressure 2d shock wave, psi				
Blast gauge 1	0.25	0.12	0.17	0.11‡
Blast gauge 2	0.26	0.13	0.17	0.11‡
43. Pressure 3d shock wave, psi				
Blast gauge 1	None	0.20	0.26	0.35‡
Blast gauge 2	None	0.23	0.26	0.35‡
		Yield Information		
44. Bhangmeter time to minimum, msec	6.0	12.5	15.5	20.0
45. Yield, Bhangmeter, kt	3.6	15.6	24.0	40.0
46. Yield, fireball growth, kt	3.1 ± 0.3	16.0 ± 0.1		30.5 ± 1.5
47. Yield, radiochemistry, kt				
48. Pressure, mb				
Burst	840	835	832	838
Ground	877	827	876	878
49. Temp., °C				
Burst	9.8	11.2	12.0	8.4
Ground	11.4	5.3	15.5	11.3
50. Relative humidity, %				
Burst	27	14	58	18
Ground	28	14	43	17
51. Alt. set. (in. Hg)	30.19	30.02	30.16	30.32
52. Altitudes, ft, for stated pressures:				
850 mb	5,070	4,880	4,960	5,140
700 mb	10,270	10,130	10,200	10,330
500 mb	18,960	18,800	18,870	19,070
400 mb	24,400	24,190	24,340	24,510
300 mb	31,000	30,650	30,970	31,170

*N latitude.
†W longitude.
‡Times and ranges given are for B-50 No. 7169. See text for details.

[redacted]

[redacted]

Item 21 gives the coordinates of the targets used in the Nevada Central Zone system. The origin (N0,E500,000) of the Nevada Central Zone transverse Mercator projection is at N latitude 34°45′, W longitude 116°40′.

Item 22 is the plotted position of the targets in latitude and longitude. These coordinates were calculated by linear interpolation between known equations at the corners of the NPG. The geodetic markings on the mosaic do not agree exactly with these positions but appear to be accurate to about 1 min.

Items 23 and 24 give the circular error as plotted by EG&G. Limits of accuracy are given.

Item 25 is a time of detonation as recorded by a camera in the photopanel. This time, when used with the release time as given by item 14, will give time of fall. This time is not so accurate as the time of fall stated in item 26 but indicates the accuracy of a photopanel timing system as a backup for the Consolidated recorder method.

Item 26 is the time of detonation as recorded by EG&G. This time was recorded with WWV as the standard.

Items 28 and 29 state the measured burst altitude as recorded and plotted by EG&G. Limits of accuracy are given.

Items 30 to 33 give the plotted slant ranges from the point of detonation to the drop aircraft at detonation and shock-wave-arrival times. Note that the slant ranges given for E shot are to B-45 No. 001, whereas the recording instruments were in B-50 No. 7169. In correcting for ranges to B-50 No. 7169, it must be remembered that this aircraft was positioned approximately 500 ft higher than, and 500 ft to the rear of, the B-45 drop aircraft.

Items 34 to 37 give the times as recorded in B-50 No. 7169. Release is taken as the start, and all times are stated from release. The timing accuracy of the first three drops is ±0.003 sec. In the case of the [redacted] drop, a delay of approximately 40 msec was incorporated in the recording equipment until release was indicated. The times given by E shot have been corrected to include this time delay. Timing accuracy for the last drop is ±0.005 sec.

Items 38 to 40 have a timing accuracy ±0.003 sec for the first three drops and ±0.005 sec for the last drop. These times are merely subtractions of time of fall given by item 34 from times given by items 35 to 37.

Items 41 to 43 give the overpressures as recorded by the two channels having blast gauges. The recording for each channel is given, channel 1 is the top figure and channel 2 is the lower figure. It must be remembered that the sensitivity of the system was set for accurate times to the leading edges of the shock waves, and overpressure readings are given with an accuracy of ±20 per cent.

Items 45 to 47 give the various yields. Item 45 gives yields as determined from the recorded Bhangmeter time-to-light minimum given in item 44. This yield was gathered from an empirical formula and appears to be accurate to ±20 per cent. Item 46 is a yield figure as computed by EG&G from high-speed cameras. The accuracy is stated for each case. The radiochemistry yield figures for item 47 can be obtained from LASL.

Items 48 to 52 give the requested climatological data. Further detailed information can be found in the Air Weather Service Buster-Jangle reports WT-342 and 361.

[redacted]

[redacted]

APPENDIX A

BASIC DIRECTIVES

A.1 EG&G AIRBORNE INSTRUMENTS*

In the initial directive authorizing the installation of airborne instruments, by command of Brigadier General Mills, it was requested that the following listed equipment be installed aboard a B-50 No. 7169 aircraft: one disk camera with associated timing equipment and two self-contained electric Bhangmeters.

It was stated that no arrangements need be made for the transfer of the disk camera in the event that B-50 No. 7169 be replaced by a spare B-50D.

No airborne EG&G instruments were required for the B-45 No. 48001.

The equipment was to be EG&G equipment, which was to be furnished to the 4925th Test Group (Atomic). It was further stated in the directive that the 4925th Test Group (Atomic) had already been contacted by Gaelen L. Felt, LASL, concerning the instrumentation.

A.2 IBDA Data†

In the directive authorizing the inclusion of IBDA data in the report, by command of Brigadier General Mills, it was requested that a report concerning the data pertaining to the IBDA program as listed below be prepared for SWC headquarters at the earliest practical date.

It was stated that the Special Weapons Center was in receipt of a letter from the SAC urgently requesting these data, and it was specified that the report include the following:

1. Actual time of fall (item 34).‡
2. Exact bombing altitude (items 6 and 7) and ground speed (item 10).
3. Intensity of the shock wave hitting the airplane if this information was available (items 41 to 43).
4. Time of arrival and separation of shock waves (items 35 to 40).
5. Position of the aircraft at time of arrival of the shock wave (items 31 to 33).
6. Actual height of burst of the bomb (item 28).

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*Information contained in a letter by Maj Oliver M. Noland, USAF, to the Commanding Officer, 4925th Test Group (Atomic): WCE 400.112 CT, EG&G airborne instruments, dated Sept. 18, 1951.

†Information contained in a letter by Col D. E. Hooks, USAF, to the Commanding Officer, 4925th Test Group (Atomic): WCR 471.6, IBDA data, dated Nov. 26, 1951.

‡Item numbers listed in parentheses refer to Table 3.1 where specific data may be found in answer to the requests made in this directive.

[redacted]

[redacted]

Fig. A.1—Nevada Proving Grounds, Area 7, aerial view.

[redacted]

[redacted]

7. Yield of the bomb (items 45 to 47).

8. Location of ground zero (items 21 and 22) and topographical features within five miles of ground zero (see Fig. A.1).

9. Climatological conditions existing at time of burst (items 48 to 52).

10. Rate of growth and maximum diameter of fireball if this information was available. (This information may be obtained from J-Division, LASL.)

11. Bhangmeter reading (item 44).

The directive further requested that any other information be given or that pertinent comments be made.

[redacted]

[redacted]

APPENDIX B

PERSONNEL AND EQUIPMENT

B.1 PERSONNEL

Personnel who participated in, or directed, the instrumentation of B-50 No. 7169 are listed in this section. With each participant is given the position he filled or the duty he performed.

B.1.1 4925th Test Group (Atomic) Technical Projects Division

Capt Otis R. Hill was Project Officer and Weaponeer, Capt E. R. Follensbee was Assistant Project Officer and Assistant Weaponeer, and Maj Richard C. McAdam was Special Airborne Equipment Operator. M/Sgt Eugene Simms processed airborne film. Erwin J. Klink, Alfred R. Kilbey, and Charles B. Aufill installed airborne instrumentation. Howard W. Schmalle prepared equipment-installation diagrams. Mrs. Shirlee G. Burd reduced data.

B.1.2 4925th Test Group (Atomic) Materiel Division

WO Victor Wiley supervised aircraft modification and installations.

B.1.3 Edgerton, Germeshausen & Grier

Lewis Fussel, Jr., was the Bhangmeter and disk-camera consultant. Arthur K. Drake was the Bhangmeter technician. Charles W. Wyckoff was the photographic consultant.

B.2 EQUIPMENT LIST

This section lists the equipment used in the instrumentation of the B-50 No. 7169 for Operation Buster drops.

B.2.1 Disk Camera, Installation for EG&G

1. Disk camera.
2. Trigger box.
3. Blue Box fiducial Type A-1.
4. Marker head.
5. 200-cps gated marker.
6. B-7 intervalometer.
7. Necessary cabling.

[redacted]

[redacted]

B.2.2 IBDA, Installation for WADC

1. K-24 camera.
2. T-11 camera.
3. T-11 photoelectric-cell pickup.
4. T-11 power supply.
5. O-15 radar camera.
6. O-15 control box.
7. B-7 intervalometer.
8. Necessary cabling.

B.2.3 Transit-time Telemeter-control Installation for Sandia Corporation

1. Transit-time telemeter-control panel.
2. Rf field-strength meter.
3. Necessary cabling.

B.2.4 4925th Test Group (Atomic)

1. Hewlett & Packard model 100D frequency standard.
2. Consolidated Type 5-14 multichannel recording oscillograph.
3. Consolidated Type 112 linear integrating amplifier.
4. Sensicon fm tone receiver.
5. EG&G Blue Box fiducial Type A-1.
6. Photographic panel recording flight instruments.
7. 136- and 150-Mc tone transmitters.
8. Tone-transmitter power supplies.
9. 218-Mc rf signal-strength meter.
10. Necessary cabling.

[redacted]

[redacted]

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University of California Radiation Laboratory, Livermore	18–19
Weapon Test Reports Group, TIS	20
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